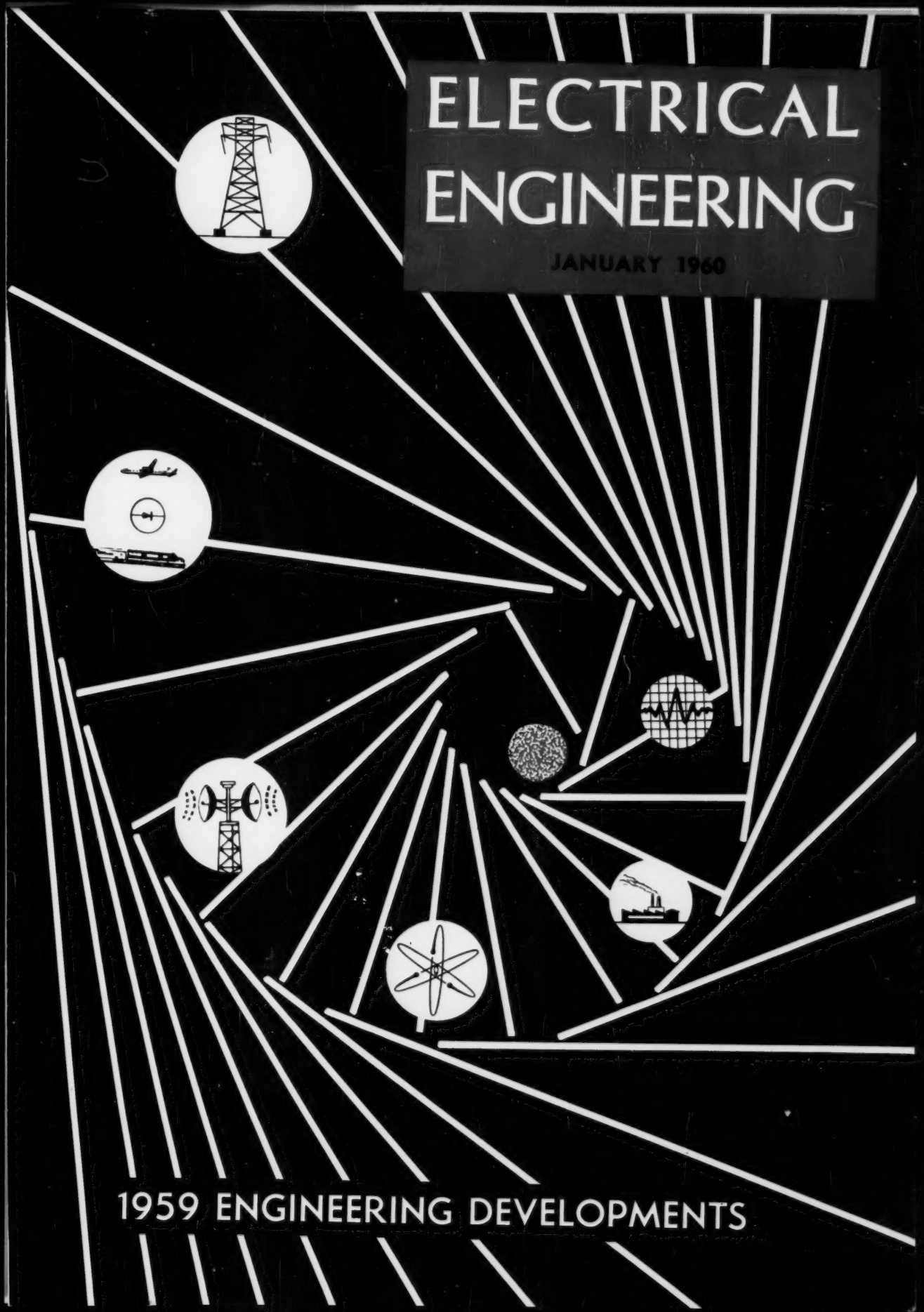
ELECTRICAL ENGINEERING

JANUARY 1960



1959 ENGINEERING DEVELOPMENTS

Now . . . for your Medallion Homes

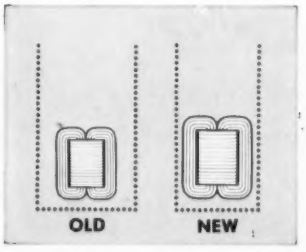
KUHLMAN *Perma-Gold* TRANSFORMER

looks good as gold . . . and is!

The Kuhlman "Perma-Gold" Transformer, designed to serve your Medallion Homes, will add real distinction to your "showcase" neighborhoods and developments.

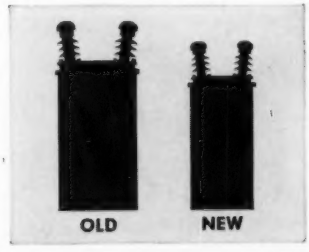
This distinctive Kuhlman transformer, with its gleaming gold color, spells prestige for the utility, for the builder and developer of the all-electric neighborhood, and for the people who live in the Medallion Homes the transformer serves.

Kuhlman "Perma-Gold" Transformer, available in conventional or CSP pole-type ratings, is a symbol of the great achievements of the electrical industry, and a symbol of Kuhlman's own achievements in transformer design and efficiency.



BIGGER INSIDE

New design allows Kuhlman to build a larger core and coil, using more copper and steel. This provides improved impedance, lower losses, and better regulation.



SMALLER OUTSIDE

Shorter, slimmer tank takes up less room on the pole. Small size offsets increased weight of stepped-up core and coil.

Ask your Kuhlman representative to give you all the facts about how the Kuhlman "Perma-Gold" Transformer will build the prestige of your all-electric communities.

KUHLMAN TRANSFORMERS

KUHLMAN ELECTRIC COMPANY, Birmingham, Michigan

Manufacturers of transformers since 1894

PLANTS: Bay City, Mich.; Crystal Springs, Miss.; Salinas, Calif.

ELECTRICAL ENGINEERING

JANUARY 1960
Vol. 79, No. 1

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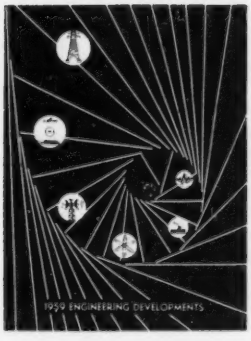

THE COVER: The expanding influence of electrical engineering, represented by the six AIEE Divisions—Communication, General Applications, Industry, Instrumentation, Power, and Science and Electronics, is depicted on this month's cover, which was designed by Remo Cosentino.

Published monthly by American Institute of Electrical Engineers

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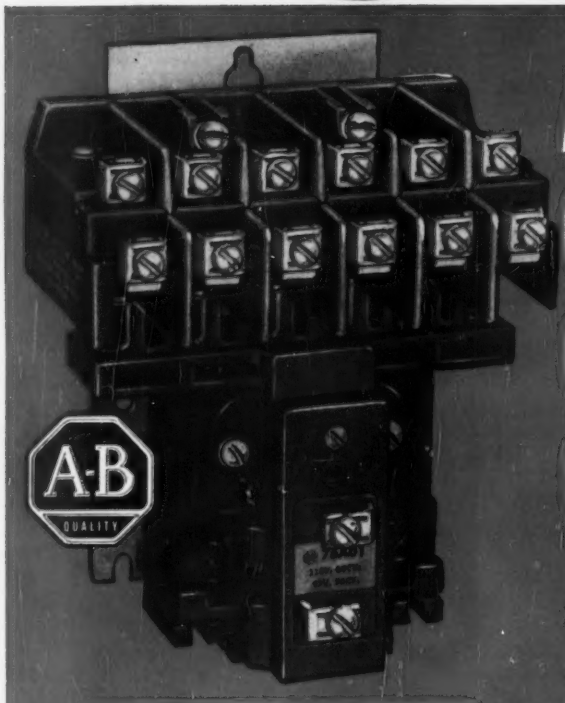
IT'S NEW



Bulletin 700 Type BR Relay with all six of the convertible poles arranged for normally open contact operation.

Allen-Bradley Convertible Contact CONTROL RELAY

BULLETIN 700

TYPE BR

Changeover made in seconds!

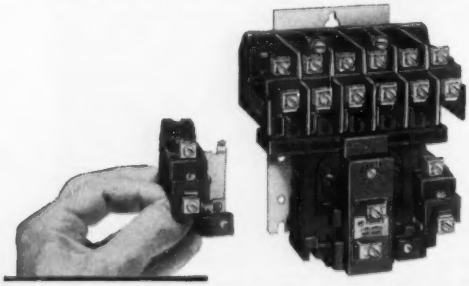
The contacts of the new Type BR relay can be arranged for either normally open or normally closed operation—and any changeover in the field can be made in seconds. A screwdriver is all that's needed.

This new A-B Bulletin 700 Type BR relay is ideal for use on automatic machines where control functions are frequently altered to meet production changes.

Quick convertibility of the contacts enables easy "on-the-spot" changes—from "normally open" to "normally closed"—or vice versa.

These new Bulletin 700 Type BR relays have been exhaustively tested to make sure that they will provide the many millions of trouble free operations for which all A-B controls are famous. In fact, the Bulletin 700 Type BR relays will establish new standards for long relay life and "reliability" of contact operation. Of course, they have double break, silver contacts that never need attention; also, the cast-plastic coil is impervious to the most severe atmospheric conditions.

Please write for full details, today!



Two extra convertible poles can be easily added—in the field

An auxiliary convertible contact pole—having full switching capacity—can be easily added to the left and right sides of the Type BR relays. These auxiliary poles are front-mounted and can be added without disturbing the wiring of the relay—and without removing the relay. All relays are designed to also accept stab connectors, and—all terminals are accessible from the front.

Allen-Bradley Co., 1301 S. First St., Milwaukee 4, Wis. In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

ALLEN-BRADLEY Member of NEMA — **QUALITY MOTOR CONTROL**

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negligible maintenance . . . 94-97% efficiency!

Silicon's long life, stability and ruggedness have made possible industrial rectifiers which far outperform older conversion equipment both in reliability and efficiency. Perkin silicon rectifiers cover the full useful range of all other types of converters, cost less, install easily, are self-contained in a single compact enclosure (require no control panel), and are virtually maintenance-free. Use them for greater economy and dependability in powering chemical processes, machine tools, elevators, dc motors and controls – in fact, in *any* dc power application. Prompt delivery anywhere.

Overload protection to NEMA standards

All units completely self-protected for short circuits – coordinated protection of diode fuse, output fuse and input breaker..

Elements stay cool under severest conditions

To realize the long-life potential of silicon rectifier elements, Perkin fan-cools them during operation to just 40% of the manufacturer's recommended temperature rise!

Forced balance of voltage and current

Forced equality of voltage and current distribution prevents overloading or damaging of rectifier elements, even under severest conditions – no need to match replacement junctions.

Suppression of surges and transients

Capacitors and nonlinear resistor suppressors together with high-voltage-capacity rectifier elements make equipment fully surge proof.

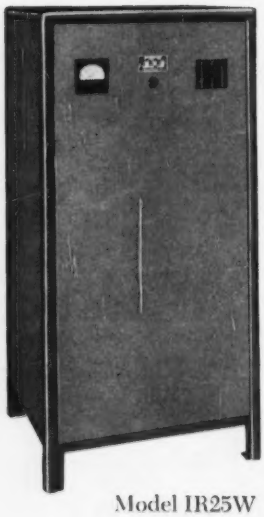
Highest quality silicon diodes

All equipment uses the finest high-temperature, hermetically sealed silicon rectifier elements. Bond is metal-to-glass – no organic binders or potting compounds are used.

Optional Features

Where you need extreme reliability, Perkin can add a spare rectifier element in each string. If one element fails, remaining units maintain voltage. Fuse indicator lights pinpoint the bad element. In rectifiers of 200kw and over, an optional feature lets you replace elements and fuses *under load* safely and without interrupting operation.

PERKIN



Model IR25W

NOW...A STANDARD SILICON RECTIFIER FOR EVERY PURPOSE!
MODEL NUMBERS

KW Rating	DC OUTPUT VOLTAGE			
	125 V 2-wire	250 V 2-wire	125/250 V 3-wire	600 V 2-wire
25	IR25W	IR25X	IR25Y	
50	IR50W	IR50X	IR50Y	
75		IR75X	IR75Y	
100		IR100X	IR100Y	IR100Z
150		IR150X	IR150Y	IR150Z
200		IR200X	IR200Y	IR200Z
300		IR300X	IR300Y	IR300Z
400		IR400X	IR400Y	IR400Z
500		IR500X	IR500Y	IR500Z

Available ac input voltage (3 phase, 60 cps)

208v	to	600v	for	25,	50,	&	75kw
440v	to	600v	for	100,	150,	&	200kw
440v	to	13,800v	for	300,	400,	&	500kw

PERKIN

Model JR500Z

Overload: 125% for 2 hrs., 200% for 1 min. Meets all NEMA standards.
Efficiency: 94-97% at rated load.
Power factor: 94% at rated load.
Voltage ripple: 2% rms.
Regulation: 5% from 1% F.L. to F.L.

In addition to the standard industrial rectifier line above, Perkin has also furnished many rectifiers to the chemical, steel, shipyard, utility and other industries. Installations which have been in operation for many years include 10,000kw (up to 900v dc) at the Atomic Energy Commission, and 2000kw shipside dc power. Perkin has recently produced an 8000kw and a 4000kw silicon rectifier for two major chemical firms.

Write, on your letterhead, for detailed technical information indicating your specifications, or for a copy of our latest technical article, "Industrial Semi-Conductor Rectifiers."

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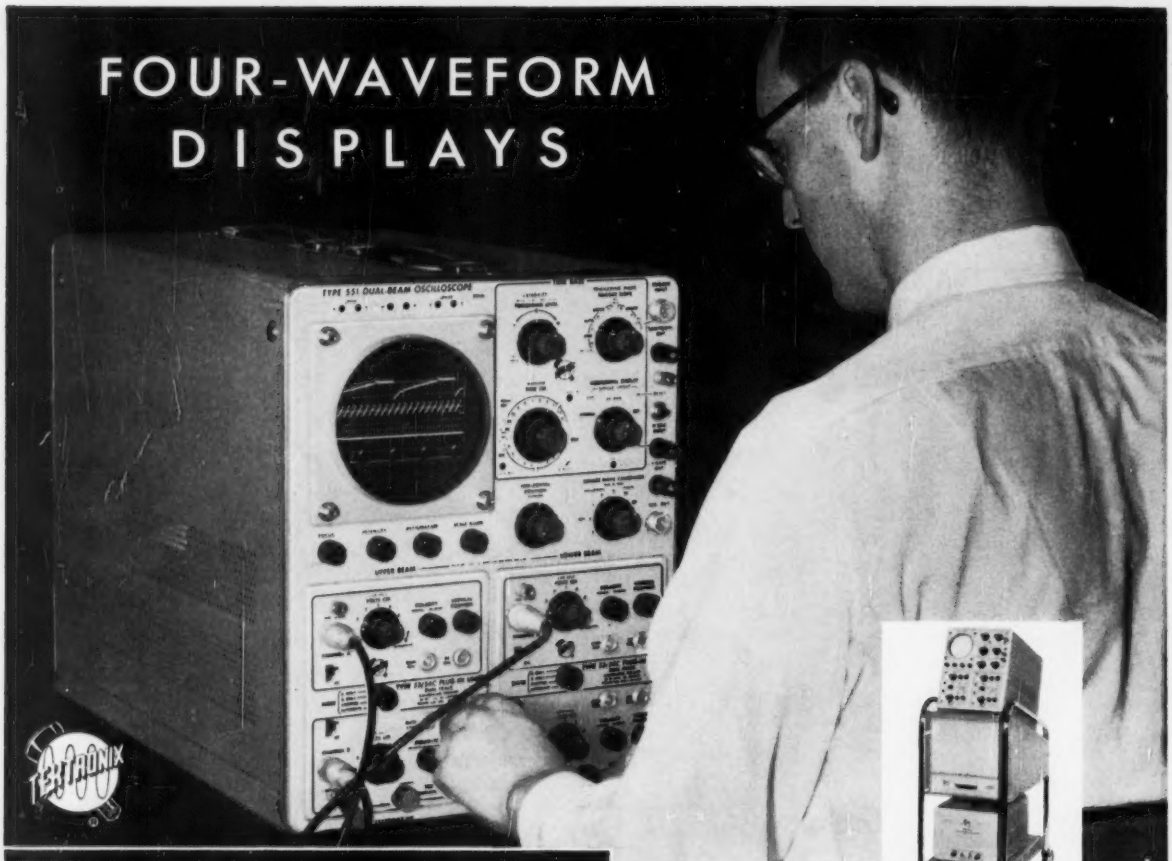
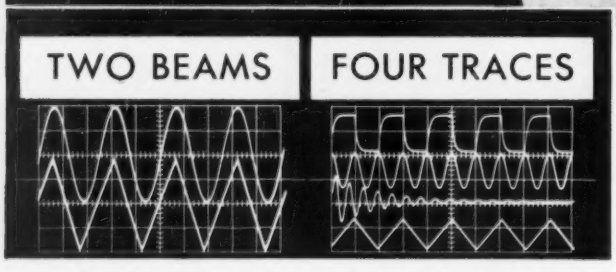
FOUR-WAVEFORM DISPLAYS





When the job requires it, you can double up and display four different waveforms at once with this dual-beam oscilloscope. Type 53/54C and/or Type C-A Dual-Trace Plug-In Units in both channels make possible the four-trace display.

Less spectacular but more frequent uses of this versatile fast-rise oscilloscope include waveform comparison measurements on a dual-beam display in the dc-to-25 mc range, and all the usual and unusual applications of a high-performance laboratory oscilloscope.

PRICE
without plug-in units **$1800**
Type 500/53A
Scope-Mobile **$110**
Type K Fast-Rise
Plug-In Preamplifiers, each **$135**
Type C-A Dual-Trace
Plug-In Preamplifiers, each **$250**
(f.o.b. factory)

ENGINEERS—interested in furthering the advancement of the oscilloscope? We have openings for men with creative ability in circuit and instrument design, cathode-ray tube design, and semiconductor research. Please write Richard Ropiequet, V.P., Eng.

Please call your Tektronix Field Engineer or Representative for complete specifications and, if desired, to arrange for a demonstration at your convenience.

TYPE 551 DC-to-25 MC

Special Features

WIDE-BAND VERTICAL AMPLIFIERS
Main-unit risetimes—12 mμsec.
Passbands and risetimes with Type K (53/54K) units—dc-to-25 mc, 0.014 μsec.

SIGNAL-HANDLING VERSATILITY
All Tektronix A to Z Plug-In Preamplifiers can be used in both channels.

0.2 μsec DELAY NETWORKS

WIDE SWEEP RANGE
0.02 μsec/cm to 12 sec/cm.

SINGLE SWEEPS
Lockout-reset circuitry.

COMPLETE TRIGGERING
Fully-automatic or amplitude-level selection with preset or manual stability control.

10-kv ACCELERATING POTENTIAL
Brighter display for fast sweeps and low repetition rates.

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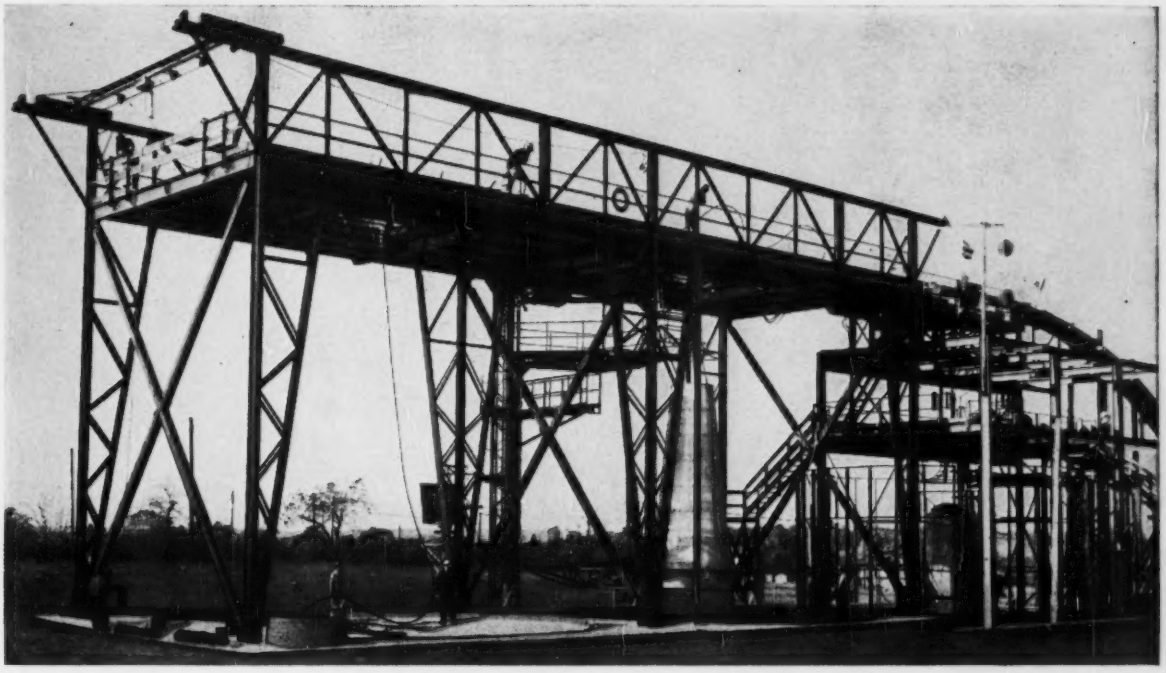
Tektronix is represented in 20 overseas countries by qualified engineering organizations.



SHIP WITHOUT AN OCEAN

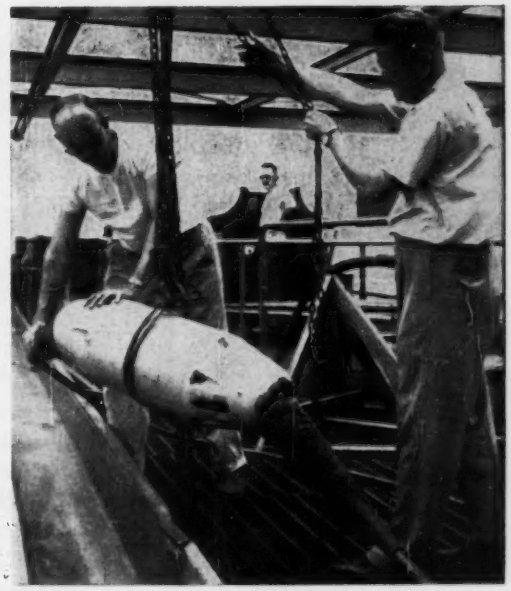
How do you lay a cable on the ocean floor—a cable that is connected to scores of large, heavy amplifiers? How do you "overboard" such a system in a continuous operation, without once halting the cable ship?

Bell Telephone Laboratories engineers must answer these questions in order to lay a new deep-sea telephone system designed to carry many more simultaneous conversations. They're experimenting on dry land because it is easier and more economical than on a ship. Ideas that couldn't even be attempted at sea are safely tested and evaluated.

In one experiment, they use a mock-up of the storage tank area of a cable ship (above). Here, they learn how amplifiers (see photo right), too rigid and heavy to be stored with the cable coils *below* decks, must be positioned *on* deck for trouble-free handling and overboarding.

Elsewhere in the Laboratories, engineers learn how best to grip the cable and control its speed, what happens as the cable with its amplifiers falls through the sea, and how fast it must be payed out to snugly fit the ocean floor. Oceanographic studies reveal the hills and valleys which will be encountered. Studies with naval architects show how the findings can be best put to work in actual cable ships.

This work is typical of the research and development effort that goes on at Bell Laboratories to bring you more and better communications services.



Experimental amplifier about to be "launched" from "cable ship." Like a giant string of beads, amplifiers and connecting cable must be overboarded without stopping the ship.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

Answer: **All but this one.**

Here is a *medium*-scale general purpose digital computer, and the only small-scale thing about it is the price. It's the low-price Bendix G-15.

Part of the remarkable success of the G-15 is due to that low price. One user writes, *". . . the nearest competitor to the G-15 costs five times as much."*

There are many other reasons why hundreds of computer experts have chosen the G-15. Versatility is one. The G-15 is well-equipped to handle all phases of business data processing as well as highly complex scientific and engineering calculations. Also, simplified programming methods allow your present personnel to solve their own problems on the computer.

A broad line of accessories means the G-15 is expandable. As the work increases, you can add magnetic tape units, punched card equipment, and other accessories. Don't forget, however, that the basic G-15, with its photoelectric paper tape reader-punch and electric typewriter, is more than adequate for most problems.

Other features you will like are: true alphanumeric input-output, high internal speed, buffering, large program library and user's exchange group, and fast nation-wide service.

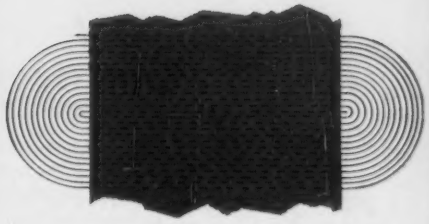
Bendix® Computer

Complete details will be sent upon request. Mention specific problems where the G-15 may be helpful, and we will be glad to advise you.

DIVISION, DEPT. K-14, LOS ANGELES 45, CALIFORNIA

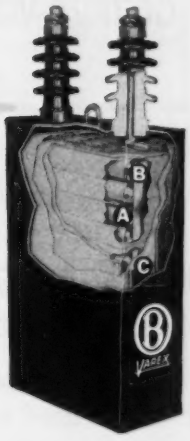
Experienced programmers, sales and service personnel . . . share our growth. Contact O. P. Staderman, Director of Marketing.

It's So Simple with Springs!



Schematic end view of Varex shows contact plate in relation to element. Note that each layer of foil contacts the plate at top and bottom.

Strong springs (c) maintain constant pressure on contact plates (b) to hold against extended foil (a).



VAREX spring-pressure system provides large contact areas outside active dielectric

An obvious design advantage in Varex capacitors is the method of making contact with the extended foil at the end of each element. Contact is maintained by strong spring pressure. This leads to these important benefits:

1 - - The electrical contact areas are generous in size and large in number. Every turn of foil is in contact both at the top and bottom of the plate. With this arrangement, current density at any single point is necessarily low . . . Varex units are better equipped to handle transient overcurrents.

2 - - With this system, winding each Varex element can be a continuous process - - uninterrupted for insertion of foreign materials to make electrical contact to the foils. A possible cause of mechanical damage to the paper dielectric is eliminated.

It's benefits like these - - adding to capacitor life and safe-guarding operation - - that argue strongly for using Varex capacitors on your system.

OHIO BRASS COMPANY, MANSFIELD, OHIO

Ohio Brass

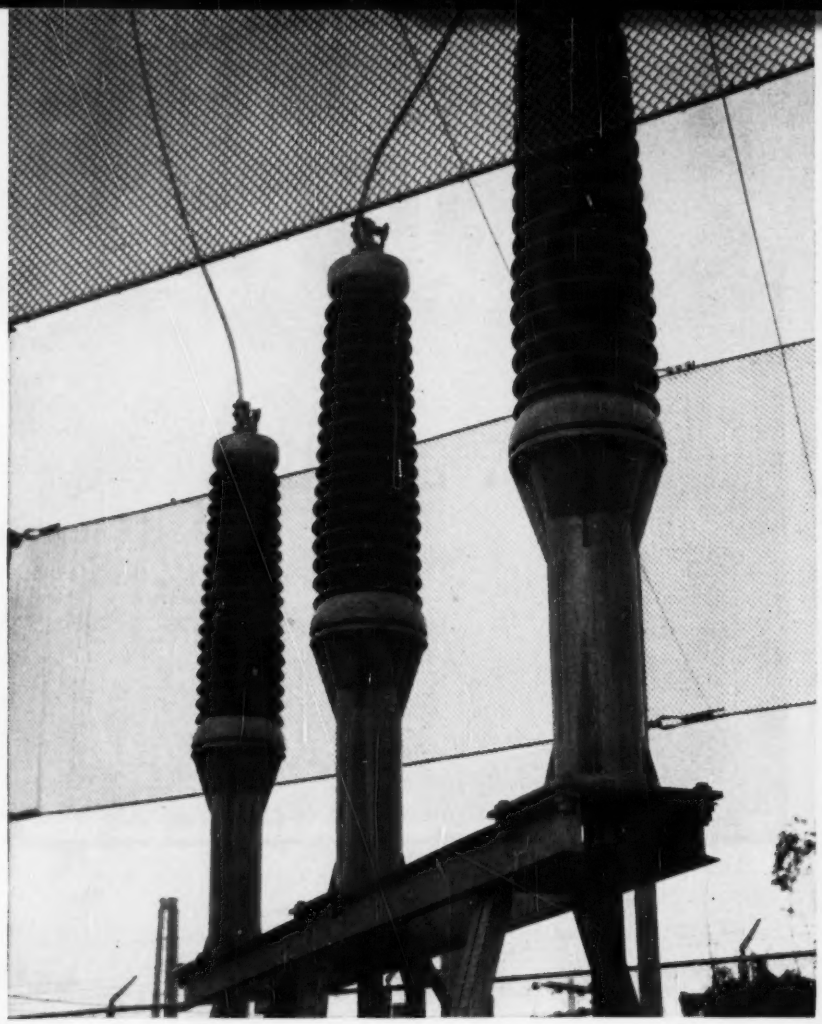
HOLAN

PORCELAIN INSULATORS · LINE HARDWARE · CAPACITORS · LIGHTNING ARRESTERS
BUSHINGS · HOLAN TRUCK-MOUNTED POWER DEVICES AND BODIES · BRONZE VALVES

4963-H1

ANOTHER FIRST from G&W

"a significant step forward in the termination of high-voltage cable"*



The first use of a commercially available

138 kv HIGH PRESSURE ALL-GAS POTHEAD

in which the porcelain is subjected to full line pressure

The very first pothead to be used commercially was designed by the founders of G&W. Over fifty-five years later and many other "firsts," G&W engineers have produced the most complete line of potheads available to industry. You can specify the pothead of your choice with utmost confidence.

G&W experience, engineering skill, and the manufacturing resources at its command are second to none. They are your positive guarantee of satisfaction.

Write today for your copy of "MORE POWER DOWNTOWN".

* *This quote is from an authoritative article titled, "More Power Downtown". The article gives full facts on new ideas used in the construction of a 110 kv underground system on the West Coast. Describes techniques you'll want to know about—"must" reading. Send for your copy today.*

G&W ELECTRIC SPECIALTY CO.

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Handle Any Adjustable-Speed Job with One of these Square D "packages"*

One of 13 CUSTOM DRIVES for an automotive plant for control of 6 miles of monorail conveyors

* *a Square D "package" includes the power conversion unit, operator's station, and drive motor*

ELECTRONIC DRIVES

employ advanced designs using more static elements and less tubes. Fail-safe circuits prevent motor runaways. Available in sizes from 1/20 H.P. through 40 H.P.

STATIC POWER MAGNETIC AMPLIFIER DRIVES

provide top reliability and simple maintenance. Save both floor space and weight as compared to conventional drives. Available in sizes through 400 H.P.

MOTOR-GENERATOR DRIVES

use static regulators and rectifiers for simplified maintenance. Rugged, heavy-duty components are provided in each drive. Available in sizes through 400 H.P.

CUSTOM DRIVES

for every possible adjustable-speed requirement can be designed for you using combinations of the above units, plus special units, with accuracies to fractions of 1%. The answer to your adjustable speed problem is as near as your Square D field office.

No matter what adjustable-speed requirements you may have, you can select a Square D drive to meet them exactly. Moreover, every component—from control to drive motor—is subjected to a complete electrical test, and the entire drive is test-run at the factory to assure top performance on the job.

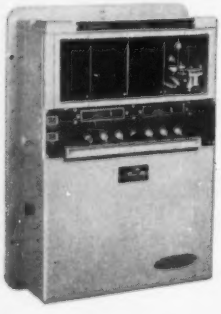
***Write** for complete details. Ask for Adjustable-Speed Bulletin. Square D Company, 4041 North Richards St., Milwaukee 12, Wis.*

SQUARE D COMPANY

wherever electricity is distributed and controlled

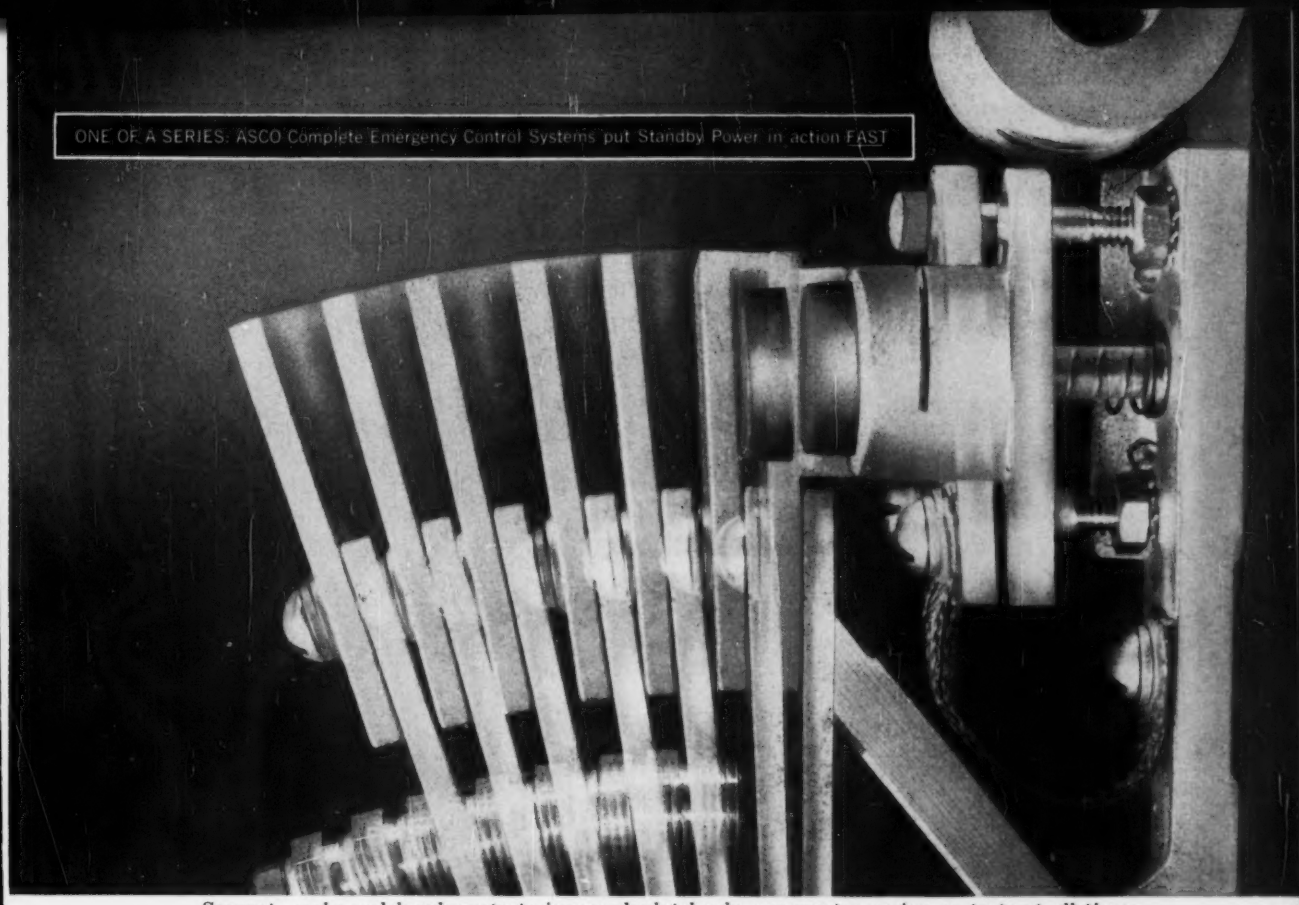
FOR CONTINUOUS EXAMINATION *of your transmission system... monitor automatically with the...*

HAMILTON *RS-9 Thirty* AUTOMATIC OCSILLOGRAPH



The RS-9 Thirty stands by, constantly monitoring your system.
Then, within 2 milliseconds after a fault occurs, your Hamilton is automatically
at work recording, on up to 32 channels, the complete sequence
of operation of your protective system. It shows when a relay or breaker, protecting
your system, is slow acting or erratic... often indicating faulty equipment
before it can cause damage and costly down-time.
Write today for complete information and specifications.

HAMILTON WATCH COMPANY
HATHAWAY INSTRUMENT DIVISION
5800 East Jewell • Denver, Colorado



Separate make and break contacts insure absolutely clean current carrying contacts at all times.

ASCO Automatic Transfer Switches transfer load in 1/30 to 1/6 of a second

When a sustained outage is detected, a contact on the ASCO Automatic Transfer Switch closes in 1/50th of a second. When standby power source attains proper voltage and frequency, the switch transfers the load to the electric plant. *Time of transfer—1/30th to 1/6th of a second—up to 30 times faster than competitive switches!* This speed reflects the extra engineering quality built into every ASCO Transfer Switch. For example, rotating weight design locks contacts in position. They cannot be pulled, jarred, or shocked loose . . . perfect electrical contact and minimum power losses are assured. Powerful mechanical linkages with single coil design provide simple, sure, two-position operation. Unique interlocking makes it impossible for both normal and emergency contacts to be opened or closed at the same time . . . gives you added assurance that power will be available when you need it.

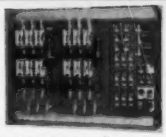
Dependable control by ASCO . . .

ASCO Electromagnetic Control

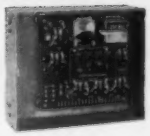
ASCO

Automatic Switch Co. 50-K HANOVER ROAD, FLORHAM PARK, N. J. FRONTIER 7-4600

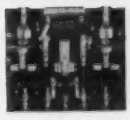
ASCO CONTROL SYSTEM COMPONENTS:



Automatic Transfer Switches *for all classes of load to 750 volts AC-DC. Transfer connected load to standby power when failure or substantial reduction occurs. Return load automatically when full power is restored — in sizes from 10 to 1200 amps. Write for Catalog 57-S1.*



Automatic Engine Starting Controls *provide fully automatic starting and stopping of diesel or gas engine driven generating sets. Write for Catalog 57-S6.*



Load Demand Controls *automatically start engine when load is applied; stop it when load is removed. Write for Catalog 57-S6.*

Solenoid Valves *for air starting applications, and for controlling the flow of cooling water, fuel oil and other liquids and gases. Write for Catalog 25.*

Battery Chargers *are designed for heavy duty industrial use. Provide power to keep engine generator cranking batteries fully charged. Charger can be combined with automatic transfer panel for compact, single package arrangements. Write for Catalog 57-S6.*

Persons in the know
are specifying fuses

HATFIELD Electric Co.,

a leading electrical contractor,
installs–

FUSETRON dual-element Fuses

in its new office building

Mr. Brown, Vice-President tells why . . .

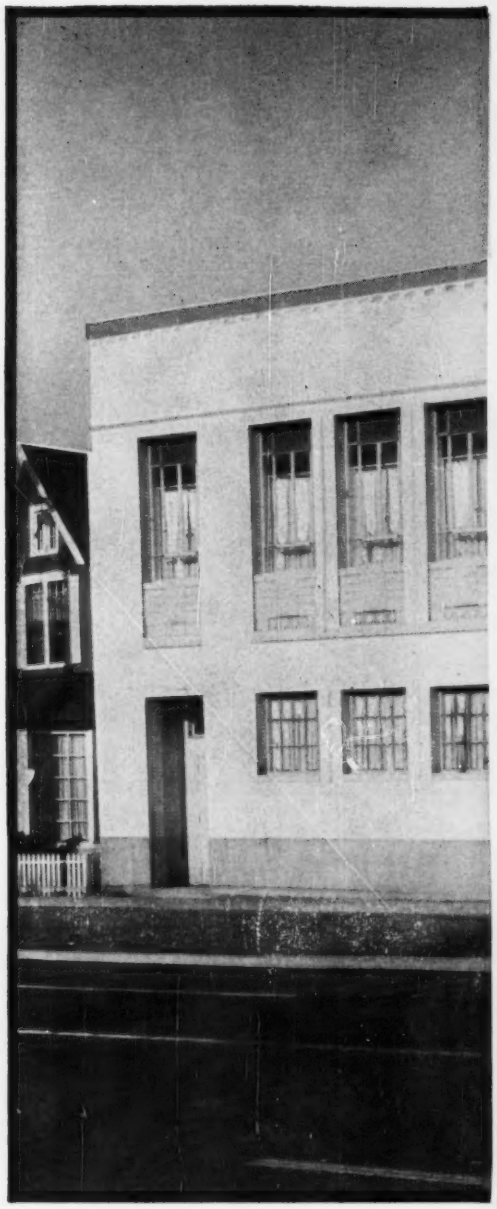
"For our own buildings and our recommendations to our industrial and commercial customers, we feel that FUSETRON fuses are the most reliable means of over-current protection that has been made available to us.

"We require protective devices for industrial and commercial application that not only provide adequate short-circuit protection but also protect against needless blows. In dead-front panel equipment it is especially desirable that they operate cool and efficiently. Of course FUSETRON fuses provide this.

"The additional protection features of these devices are of continual interest to our customers, and we feel their use is to our mutual benefit.

"As a matter of further interest, we are remotely mounting the fluorescent ballasts throughout our own offices and adding your fuse blocks with indicating FUSETRON fuses for better protection and lower maintenance."

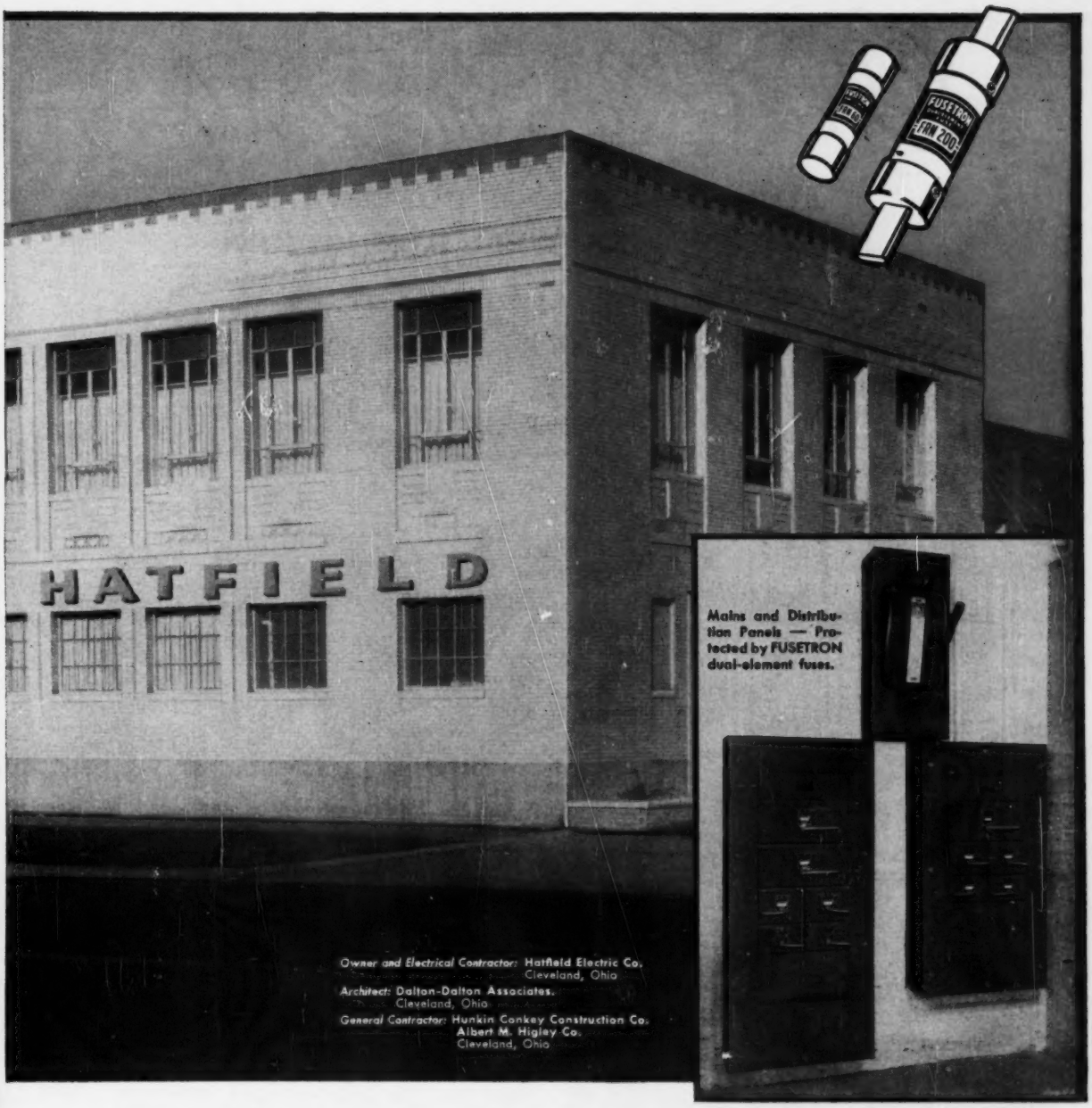
William L. Brown,
V. P. HATFIELD ELECTRIC CO.
CLEVELAND, OHIO



This Hatfield Electric Co. installation underscores the need for . . .

LIFE-TIME DEPENDABILITY AND HIGH INTERRUPTING CAPACITY IN A MODERN PROTECTIVE DEVICE — *You Get Both With* FUSETRON Fuses . . .

THERE IS A BUSS OR FUSETRON FUSE FOR EVERY ELECTRICAL NEED



Owner and Electrical Contractor: Hatfield Electric Co.
Cleveland, Ohio
Architect: Dalton-Dalton Associates.
Cleveland, Ohio
General Contractor: Hunkin Conkey Construction Co.
Albert M. Higley Co.
Cleveland, Ohio

Mains and Distribution Panels — Protected by FUSETRON dual-element fuses.

SAFE PROTECTION THROUGH THE YEARS . . .
without maintenance or recalibration costs.

FUSETRON fuses remain safe and accurate because, unlike mechanically operated devices, they have no hinges, pivots, latches or contacts to stick or get out of order.

FUSETRON fuses are *calibrated at the factory by engineers.* Once properly installed, they require no maintenance — no periodic inspection and accompanying down-time.

PROTECT AGAINST HIGH FAULT CURRENTS

A modern protective device must provide protection against today's heavy fault currents — and be able to protect against even greater fault currents that might develop in the future.

You get this protection with FUSETRON fuses. FUSETRON dual-element fuses have an interrupting rating of 100,000 amperes rms symmetrical.

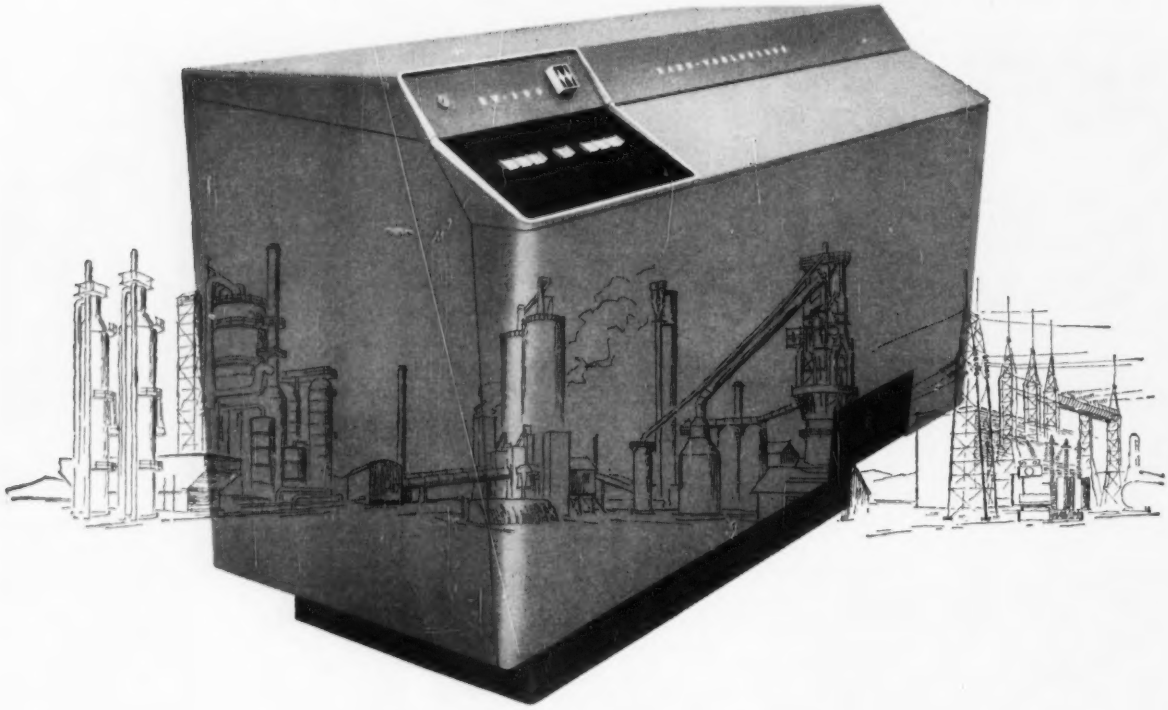
Electrical Protection goes MODERN with FUSETRON fuses because they are adequate for today's conditions and for anticipated growth in service demands.

For More Information on FUSETRON *dual-element fuses . . . Write for bulletin FIS*

BUSSMANN MFG. DIVISION, McGraw-Edison Co., St. Louis 7, Mo.

In a Class by Itself

FOR CLOSED-LOOP CONTROL AND AUTOMATIC DATA REDUCTION



The RW-300

DIGITAL CONTROL COMPUTER

OPERATING SYSTEMS incorporating the RW-300 for on-line control and data reduction are demonstrating these tangible benefits: *reduced costs, increased output, improved quality.*

HIGH RELIABILITY, inherent in the advanced design of the RW-300, is being proven by thousands of hours of dependable operation.

SYSTEMS ENGINEERING staff, experienced in the analysis of complex control and data reduction problems, is assisting industry with applications of the RW-300 in chemical, petroleum, steel, cement, electric power, and other fields.

NATION-WIDE SERVICE organization is providing skilled maintenance for this completely developed, production engineered, and thoroughly tested piece of *industrial* equipment.

For further information, call or write Mr. Raymond E. Jacobson, Director of Marketing, The Thompson-Ramo-Wooldridge Products Company, 202 N. Canon Dr., Beverly Hills, Calif., BRadshaw 2-8892.

THE THOMPSON-RAMO-WOOLDRIDGE PRODUCTS COMPANY

a division of ***Thompson Ramo Wooldridge Inc.***

ENGINEERING PROGRESS—1959

Reviewed by AIEE Technical Committees

SIGNIFICANT PROGRESS in many fields of electrical engineering during the past year has been reported by 35 committees of the Institute's six technical divisions.

In the communication field, widespread use of magnetic tape recorders in television broadcasting practically revolutionized production techniques. Big strides in data communication have been made in arrangements to provide electrical communication of data. Development of satellite radio communication systems for point-to-point communications is opening up the possibility of relaying worldwide television programs.

The General Applications Division reports substantial progress in the development of unconventional power sources for applications in space with emphasis on thermoelectrics; a healthy trend in the domestic appliance field toward more thorough engineering analysis of products and a greater amount of basic research; rapid expansion in the number of electrically heated homes; and the increasing use of electric power for all purposes aboard ship so that the ship's service system capacity on the largest vessels now being built totals 20,000 kw.

In industry, international interchange of information in the field of automatic control moved forward to reality in 1959 with the acceptance of a number of technical papers for inclusion in the First International Congress of the International Federation of Automatic Control (IFAC) to be held in Moscow, USSR, June 1960. Also noteworthy, commercial chemical computer control became a reality during the past year at the Texaco Port Arthur Works.

The instrumentation field recorded progress in the area of power measurement with the Westinghouse Hall-effect watt transducer and the Weston Inductronic wattmeter. Many advances were made in sensing elements, transducers, high-impedance electronic amplifiers, and analog measuring instruments. Marked strides were also made in mobile and point-to-point or stationary telemetering in both design and application.

The Power Division reports that the upward trend in the average size of steam-electric generating units has continued during 1959. A major advance in protective relaying equipment appeared during the past year with the first full-scale use of static components. A milestone in hydroelectric generation was reached with the award by the Bureau of Reclamation of a contract to Allis-Chalmers for the generator to fill the last remaining vacant bay in the Hoover power plant of the Hoover Dam. When installed in 1961, this unit will mark 25 years since the initial unit started commercial operation in October 1936. The past year also saw the first significant applications of digital computers in the substation field.

Some of the important developments in the field of science and electronics were the widespread acceptance of the industrial control computer; the Esaki or tunnel diode, which gives promise of most of the characteristics desired in the next generation of logic elements from low cost and high reliability to extremely high speeds (one millimicrosecond switching time); the successful operation of parametric amplifiers in military and scientific communication equipment; the establishment of a new discipline, "molecular engineering," aimed at creating functional electronic circuits which perform the composite job of several components in "monolithic blocks." A significant development in thermoelectric power devices was the 100-watt generator constructed for Rome Air Development Center by Westinghouse.

Communication

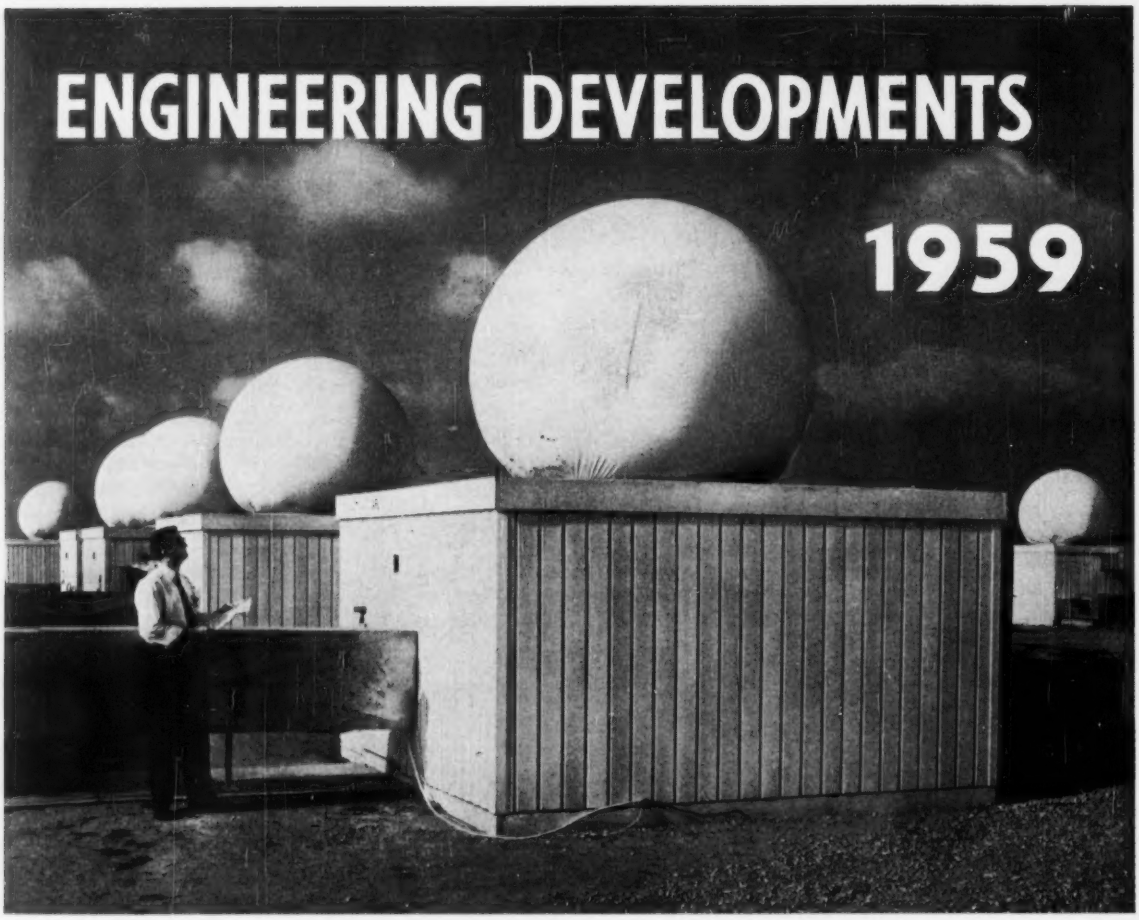
BROADCASTING

IN TELEVISION BROADCASTING there is a rapid expansion and very widespread utilization of magnetic tape recorders. This increased use of tape recorders has been so great that it has practically revolutionized television production techniques. Furthermore, educational television appears to be receiving almost complete acceptance as an aid to teaching. The present problem is not whether or not television can be used, but how it can be used most effectively. For instance, in Cortland, N. Y., the New York Telephone Company has installed

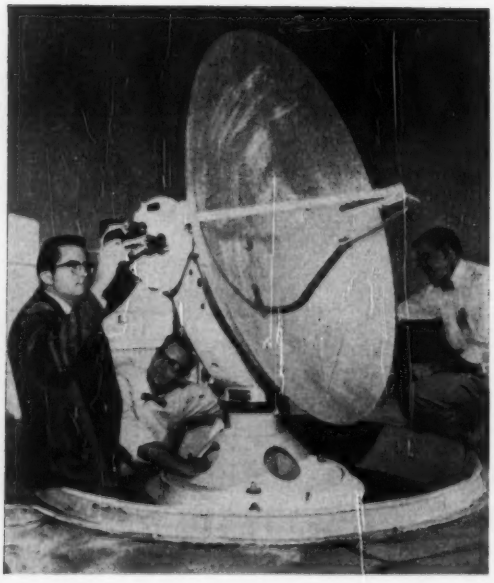
(Continued on page 30)

Comprehensive laboratory test setup of Westinghouse AM-FM duplex stereophonic system which was field tested during 1959 over radio station KDKA.

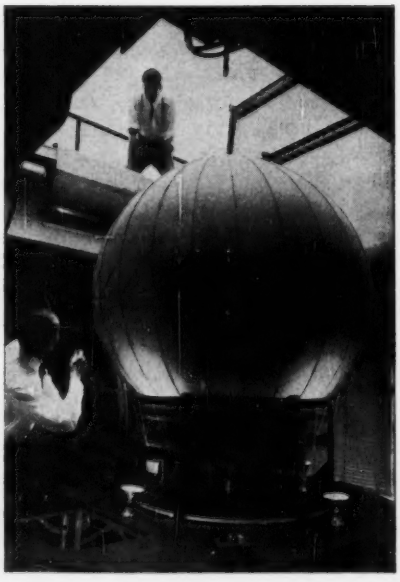
ENGINEERING DEVELOPMENTS 1959



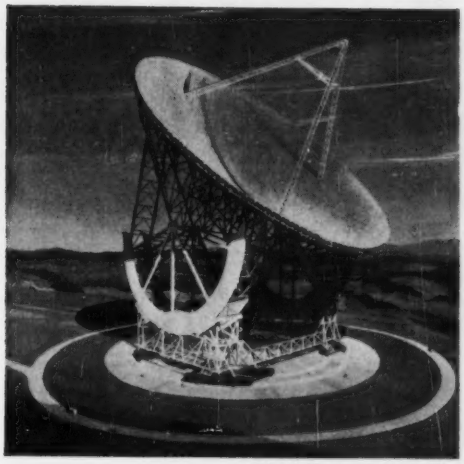
A Photographic Record of Some of the Important Electrical Engineering Achievements of the Year



▲ Azusa Mark II tracking system for the Atlantic Missile Range, Cape Canaveral, Fla., during final checkout at the San Diego facility of Convair (Astronautics) Division of General Dynamics Corporation, which developed and produced the system for the U. S. Air Force. Shown are the plastic radomes which protect the tracking system's parabolic antennas. (*Left*) One of eight antennas to be installed.

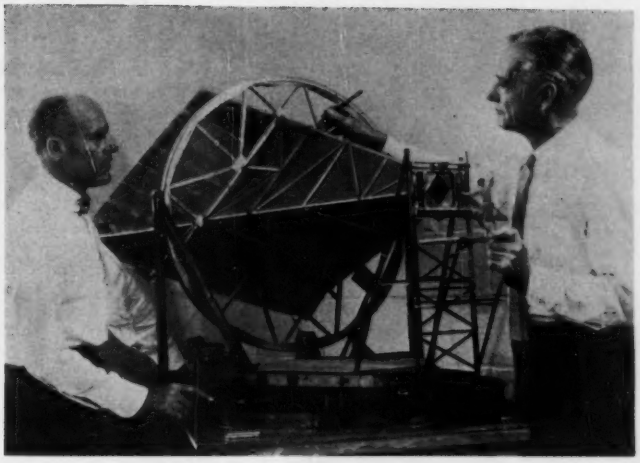


► Westinghouse Helisphere radar antenna scans the sky throughout a complete circle without any motion of the antenna structure. It operates over a considerable range of beam elevation angles.



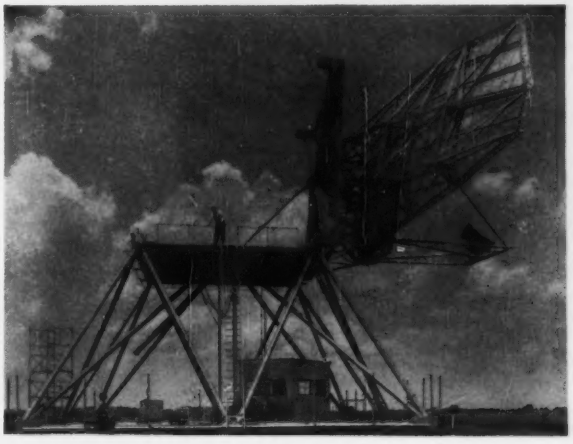
Official Photograph, U. S. Navy

▲ Artist's conception of the "Big Dish," U. S. Navy's huge radio telescope being built in Sugar Grove, W. Va. After scheduled completion in 1962, the 20,000-ton facility will enable Naval Research Laboratory scientists to tune in on radio signals emitted by astral bodies 38 billion light years out in space, 19 times the distance probed by the 200-inch Mt. Palomar optical telescope.



▲ Engineers examine model of large horn antenna which will be used at the Bell Telephone Laboratories ground station for experimental communication via man-made satellites, under construction at Holmdel, N. J. The horn antenna will be about 50 feet long and the aperture will measure about 20 by 20 feet. Figure of man at right edge of horn is in scale to size of 6-foot worker next to completed antenna. Looking over the model are Dr. W. C. Jakes, Jr., project engineer, and A. B. Crawford, who designed the horn structure.

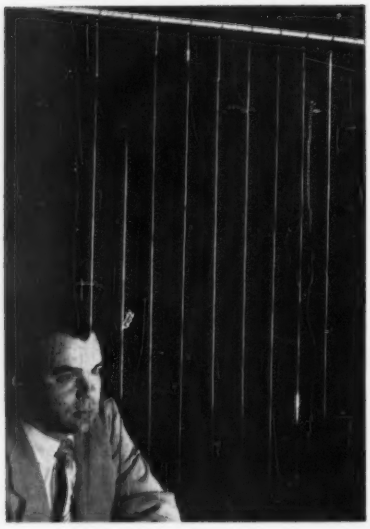
► Giant radar antenna is tested on 8,500-foot-long pattern test range at Special Products Division of I-T-E Circuit Breaker Company. The new range permits performance of pattern tests on antennas up to 60 feet wide at frequencies through 2,000 mc. Antenna shown here is slated for use on the DEW-Line eastern expansion, the "electronic fence" which warns against the approach of aircraft over the North Pole. I-T-E's 60-foot parabolic antenna for NATO's Ace High tropo-scatter communications system will be tested on this new range.



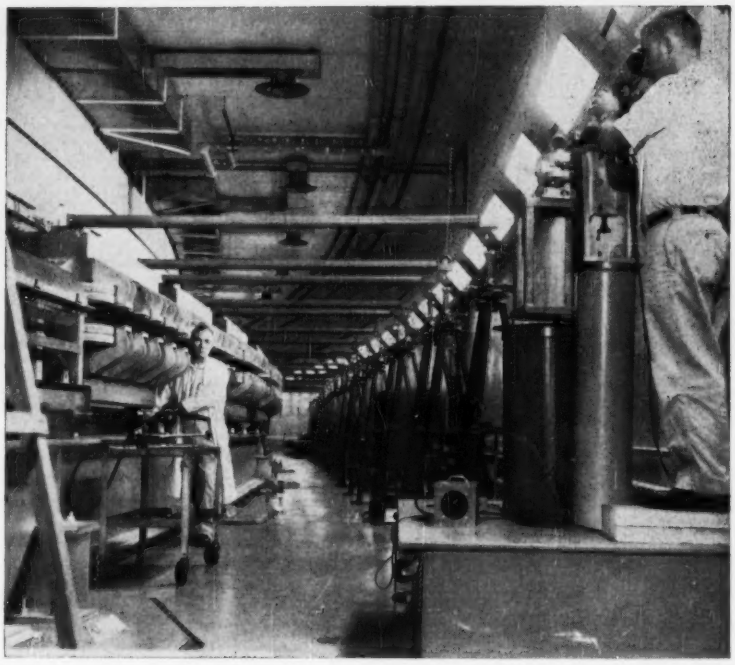
▼ A dual-reflector radar antenna, developed by Convair-San Diego, provides two different patterns in order to yield optimum performance for all operating modes. The two patterns available are a conventional-shaped beam pattern to provide proper illumination and good radar presentation when the radar is operating in the bombing or ground mapping mode and a pencil beam pattern with 4-lobe monopulse for terrain avoidance, airborne intercept, or air-to-ground tracking operation.

◄ This unique antenna system, first for nation-wide network of storm-finding radars, has been installed at the Miami, Fla., Weather Bureau. Designed specifically for meteorological use, the radar can locate and track storms over an area of 200,000 square miles, gives instantaneous data on location, size, intensity, speed, and heading over a maximum range of 250 miles. The antenna system, built by the Special Products Division of I-T-E Circuit Breaker Company, uses a 12-foot spun aluminum reflector and cast aluminum yoke and weighs less than 2,500 pounds. This lightweight construction affords a low moment of inertia to increase system efficiency and performance and component life.

RESEARCH

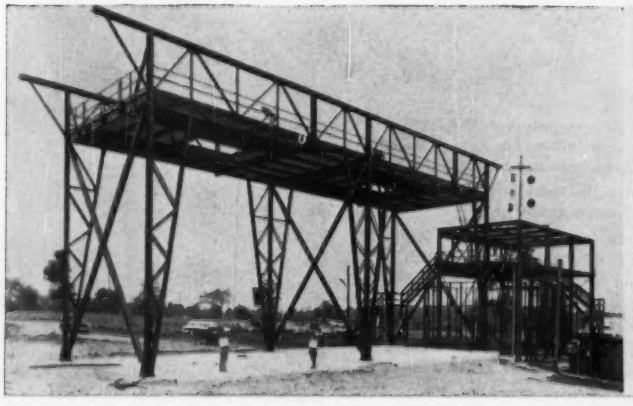


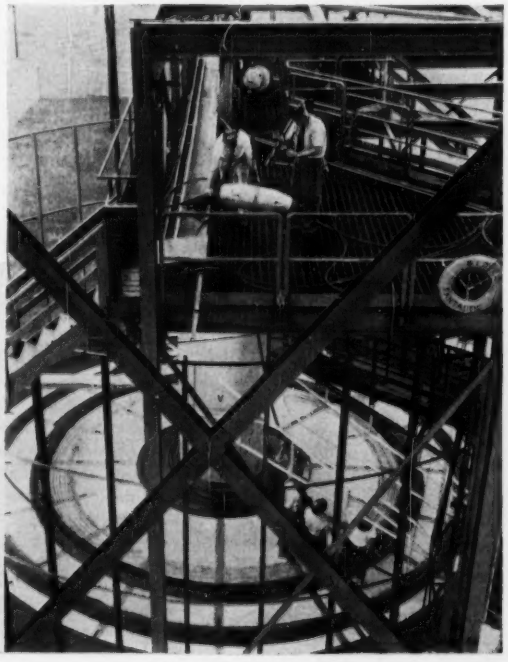
▲ Research physicist inspects mirror-like surfaces of several germanium "dendrites" grown by new method at Westinghouse Research Laboratories. The technique, the first major breakthrough in the preparation of germanium and other semiconductor materials since their commercial introduction some 10 years ago, is expected to make possible the manufacture of transistors and other devices by automatic machine. It centers on a revolutionary method of growing germanium crystals as thin, uniform, flat ribbons instead of round ingots. This method may lead to the development of outer-space electronic equipment 1,000 times smaller and lighter than anything which is now in existence.



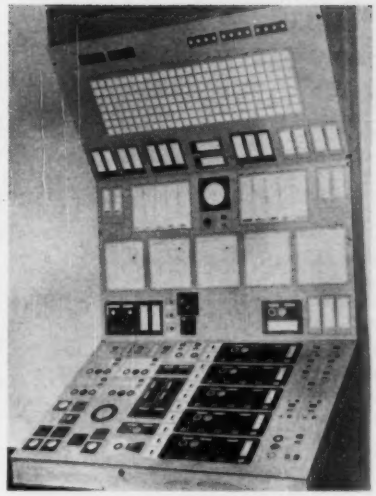
▲ View inside Brookhaven National Laboratory's Alternating Gradient Synchrotron tunnel, showing a portion of the magnet ring, which is one-half mile in length. By means of precise surveying instruments, the preliminary radial positioning of the magnets is being effected, a line of sight being taken from the primary monuments that were installed by the United States Coast and Geodetic Survey.

▼ A laboratory "cable ship," anchored firmly to a hilltop near Chester, N. J., is shown under construction. The mock-up will help Bell Telephone Laboratories engineers develop new shipboard equipment and methods needed to handle improved underwater cable systems. Cable tanks in the hold of the simulated cable ship *Fantasia* are at ground level and working decks are above. (*Right*) Simulated cable-laying activities are shown on two levels. On deck, engineers place a cable repeater model in the "highway," ready for launching, while below others work out methods of stowing cable in the "tank."

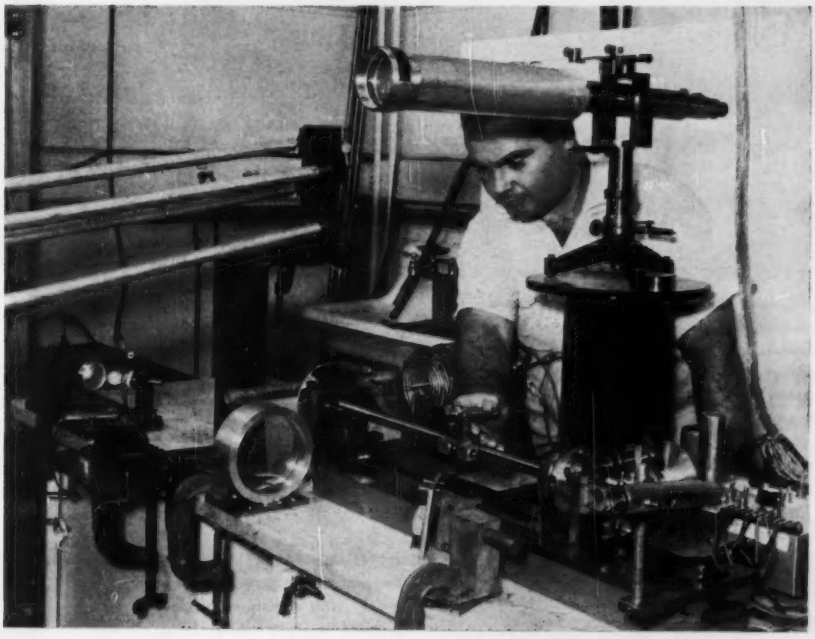




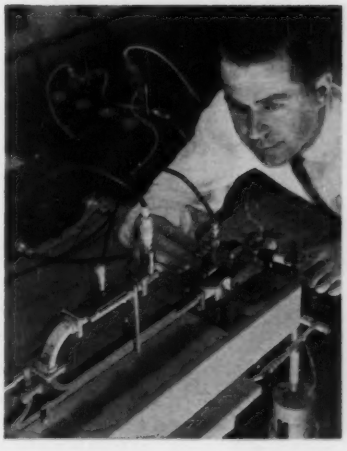
◄ Scientists at Bell Telephone Laboratories have put together on a 3- by 4-inch printed-circuit card a simple electronic device that outwardly imitates the living nerve cell, nature's tiny building block of the nervous system. Using a number of the inexpensive cells, research men are building electronic systems that imitate some of the simple workings of nerve networks in the eye and ear—the human end of the communications chain. (*Right*) Mock-up of the boiler-turbine-generator control panel installed in the Louisiana Power & Light Company's Darlington plant. The panel was designed by Ebasco Services, Inc., who handled the engineering and construction of the coal-fired station. General Electric Company is fabricating the panel.

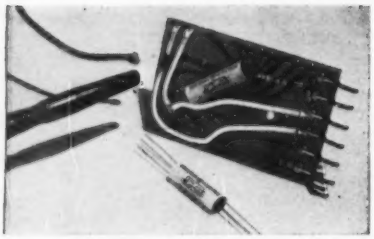


► The National Bureau of Standards has developed a photoelectric device that automatically and continuously indicates the position of the swinging beam of a high-precision balance. It also provides a greatly increased reading sensitivity, the minimum reading displacement on the scale being 0.0001 inch as compared with 0.0004 inch for the conventional visual method. The photoelectric reader can provide data on the motion of the balance beam (i. e., of the horizontal arm from which the balance pans are suspended) in two forms: (1) as a voltage whose magnitude represents the instantaneous position of the beam; or (2) as numerical data that represent turning points (extremes of the swing), from which masses may be calculated.



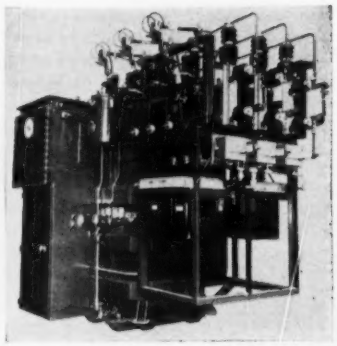
◄ Handwriting reader, demonstrated by its inventor, L. D. Harmon of Bell Telephone Laboratories, reads 10 entire handwritten words, "zero" through "nine," spelled out. It was invented to demonstrate methods which might eventually be applied in machines designed to read a wider variety of material. The electrically wired stylus is pressed to the "reset" before a word is written on the electrically connected wiring surface. When the stylus is then touched to the "identify" button, a light appears above the correct digit. (*Right*) Using equipment shown, RCA Laboratories scientists made the first experimental observation of electrons that behave as though they had negative mass and give up energy to amplify radio waves instead of absorbing them. Here the apparatus is adjusted by J. J. Thomas, research staff associate, in preparation for further experiments.





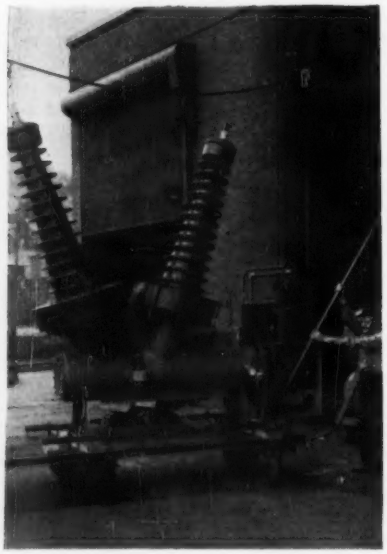
▲ General Electric Company's new Unimite general-purpose relay, less than 1 inch long and weighing only 3 grams, has a 1-millisecond operating time and may be cycled at 10,000 operations per minute. The contact chamber is hermetically sealed and isolated from the coil and contains only inorganic and chemically inert materials.

▲ General Electric's 4-pole double-throw microminiature relay minimizes one of the chief problems in achieving relay reliability—contact contamination. The 1-ounce relay is assembled, without the use of solder, by an inert arc welding process which hermetically seals the header to the can. The relay is well suited for high-temperature applications.



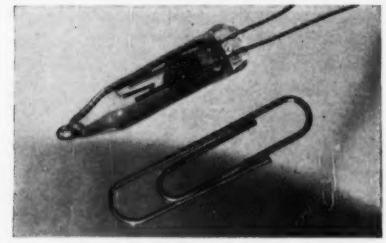
▲ Moloney Electric Company now offers "integrated substations," single or double circuit, with (1) bus disconnect, (2) bus disconnect and load disconnect, and (3) bus and load disconnects and by-pass switch. In addition, one application may easily be converted to another by adding switches and/or recloser.

POWER

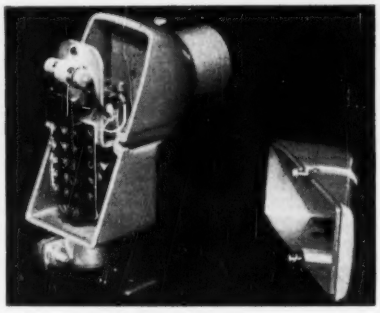


◄ "Fault-initiating" switch built by Westinghouse initiates a fault on a 230-kv line with a time consistency of ±5 electrical degrees on a rising voltage wave and ±10 electrical degrees on a falling wave. To be used for field testing power circuit breakers on a 230-kv power system, its high accuracy is necessary to control current asymmetry. The equipment involves a spring-closed device, tripped with a high-speed latch.

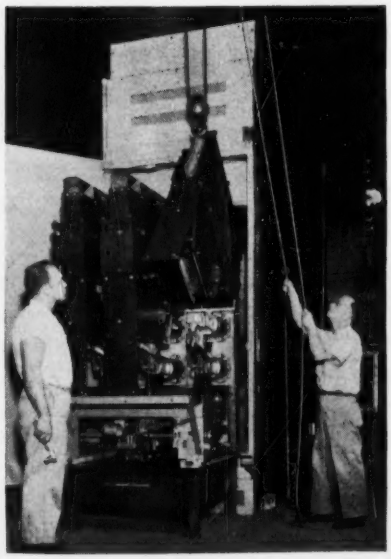
► New 1,000-mva interrupting capacity 13.8-kv air magnetic circuit breaker is checked at I-T-E Circuit Breaker Company. Features of the 3,000- and 1,200-ampere units include stored-energy closing mechanisms, high-efficiency arc chutes, and compact design. Advanced techniques and materials employed afford one-third higher interrupting capacity in virtually the same size enclosure as that for a 750-mva unit.

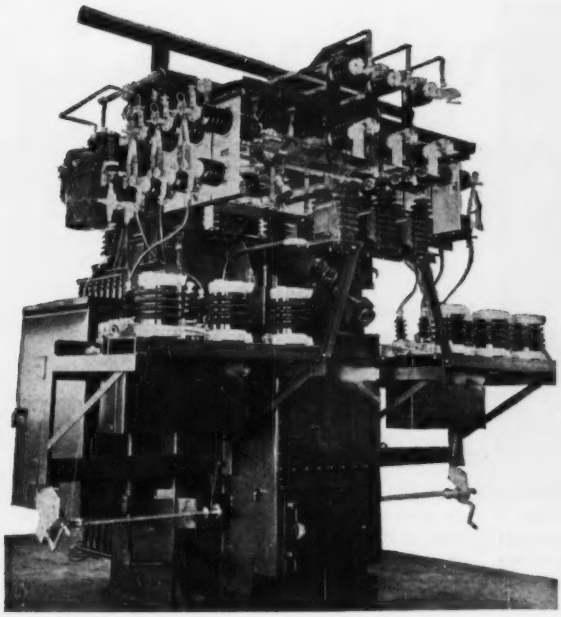


▲ Sylvania's "Mite T Breaker," a subminiature circuit breaker, is vacuum sealed in a glass envelope about the length of a common pin. The tiny, low-cost device provides circuit protection by interrupting current flow when excessive current or external heating occurs. As temperature decreases or overload is removed, current path is automatically reset.

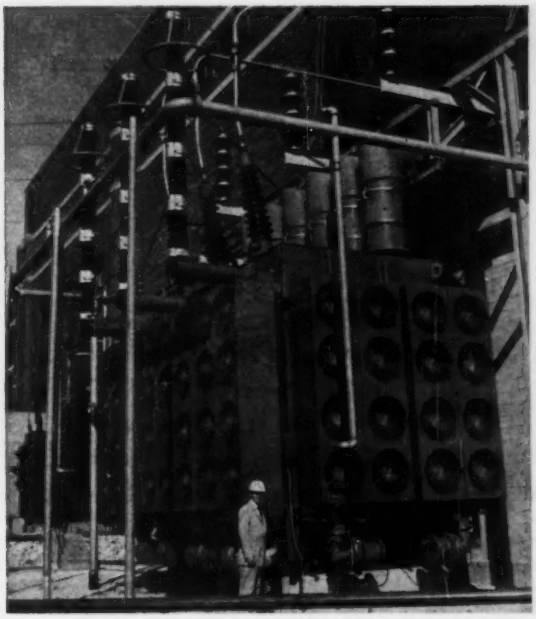


▲ Low-cost photoelectric relay, made by the General Electric Company, shown here with the back removed for easy access, needs no tubes or separate control boxes. A cadmium sulfide power cell makes the unit completely self-contained. Full operating power of 57.5 volts is drawn directly from the transformer supplying power to the light source.



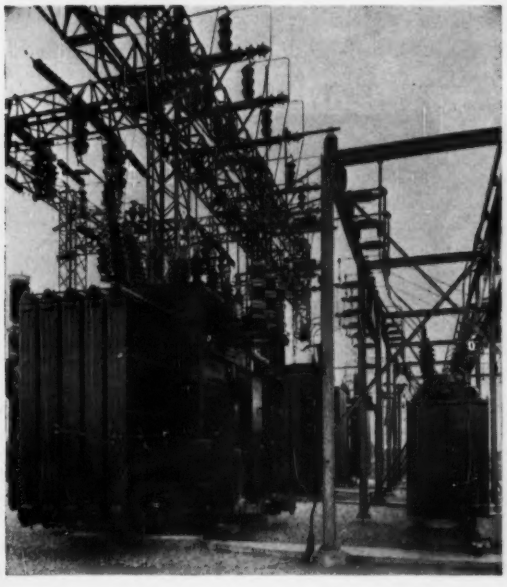


▲ One of a complete line of super-compact substations, designed primarily for application on long, lightly loaded rural or suburban power lines, now available from General Electric. According to design engineers, this substation is ideal for supplying load with minimum investment in equipment, foundations, and substation overhead structure.

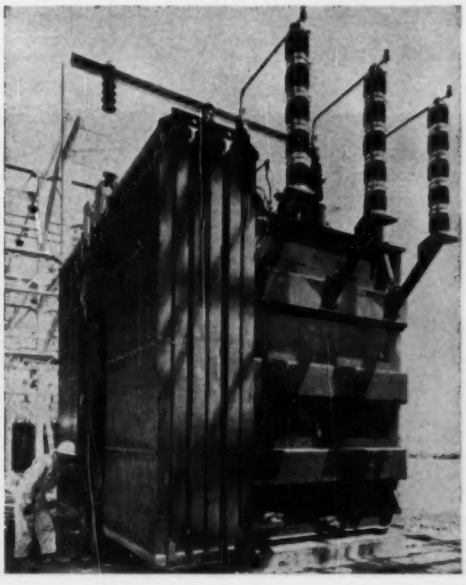


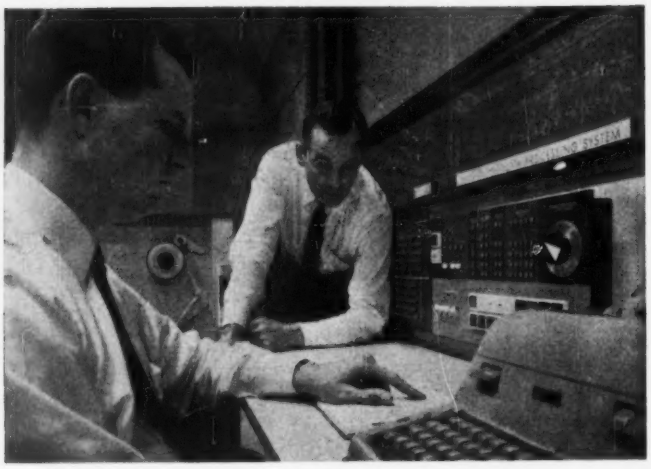
▲ This 360,000-kva 3-phase generator transformer built by Westinghouse is now operating at the Waukegan (Ill.) Station of the Commonwealth Edison Company. The generator voltage of 18 kv is stepped up to 138 kv in the forced-oil/air-cooled windings. Installed, the transformer weighs 461,500 pounds.

▼ This 30-, 40-, 50-mva OA/FOA/FOA 115-kv inner-cooled transformer weighs 3.1 pounds per kva, compared to 3.5 pounds per kva for a similarly rated conventional unit. Built by the Westinghouse Electric Corporation's power transformer department, Sharon, Pa., the unit is now installed and operating on the system of the New York State Electric and Gas Corporation at Lockport, N. Y.

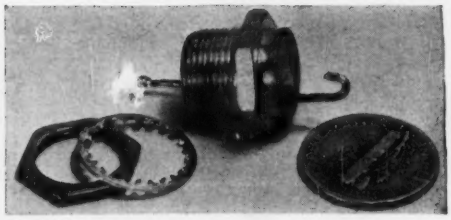


▼ "Preferred Design" power transformers, such as this one installed by the El Paso (Texas) Electric Company, can be manufactured by the General Electric Company's power transformer department using mechanized production-line techniques never before employed in the transformer field. The new program is expected to save utilities millions of dollars in 1960.

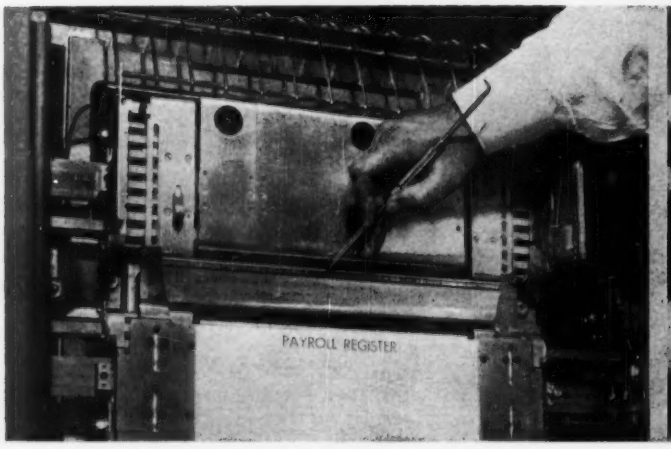


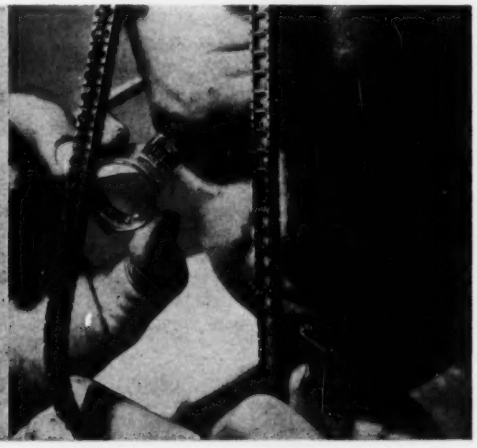


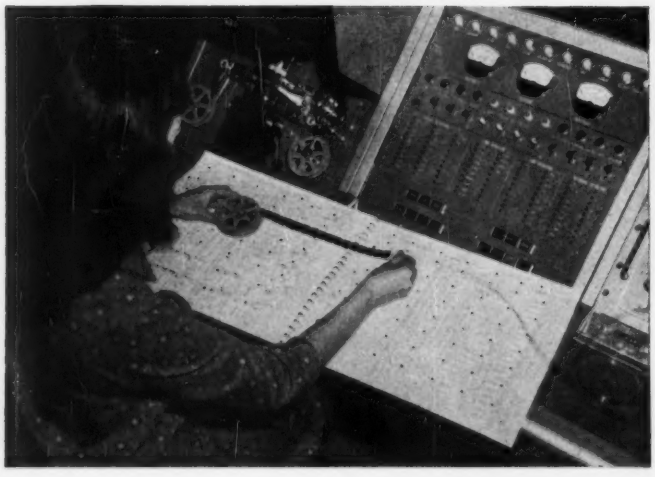
▲ Answers in split seconds to scientific and engineering problems are found by the International Business Machines Corporation 1620 data-processing system, a small computer with magnetic core memory, powerful programming techniques, and high operating speeds. It utilizes a comprehensive library of mathematical and statistical routines for fast, simplified programming, and the use of ordinary decimal arithmetic facilitates communication between the machine and operator. Built-in electric typewriter types out solutions under control of the stored program.

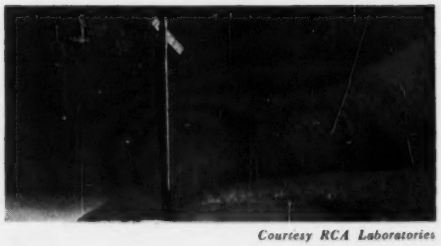


▲ Miniature low-pass r-f filters, ½ inch in diameter, have been developed by Hughes Aircraft Company for use in computers and other equipment where r-f noise is a problem. (*Below, left*) High-speed alphabet printing chain is the heart of IBM's 1403 printer, which has a speed of 600 lines per minute. Chain travels horizontally across face of paper forms at 90 inches a second. As chain moves, the impact of electronically timed hammers against individual type numbers and letters causes them to print to precise registration. (*Below, right*) Horizontal row of 132 hammers taps paper forms against inked ribbon and fast-moving endless chain of type characters. By an electronic control feature, printer automatically skips past blank lines in business forms at an accelerated rate, providing increased output of paper work.









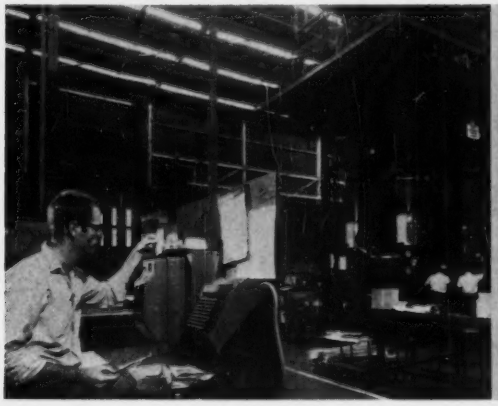
Courtesy RCA Laboratories

▲ Miniature integrated logic element will perform basic electronic computer functions now requiring a dozen or more conventional components. Device consists of small piece of silicon grooved to form several transistor-like parts that form a single integrated unit. (*Left*) Control console of FOSDIC III, developed at National Bureau of Standards to assist in 1960 decennial census. It reads microfilmed census documents and transcribes information onto tape for input to a computer.

Computers

▲ Special-purpose analog computer that analyzes heat flow in building materials has been developed by the National Bureau of Standards. This desk-sized instrument makes possible rapid estimates of transient heat flow within building materials or constructions. It makes a direct analogy between thermal and electric circuits. Although its use is not likely to eliminate the need for full-scale fire tests, it is expected to be extremely useful in reducing their number.

▲ Braille printing plate, produced electronically by an IBM *704* computer, is held by Dr. Joseph Flanagan, manager of IBM's Mathematics and Applications Department, which developed the new technique. English text is transcribed at a rate of 4,000 words per minute. This method will make it possible to increase the literature available to the blind.

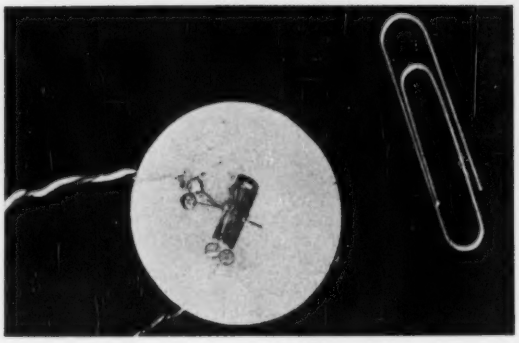


▲ Input station of IBM *357* data-collection system installed in the 10-acre fabrication shop of McDonnell Aircraft Corp., St. Louis, Mo. Prepunched card traveling with the part is inserted into reader, while variable information is transmitted by means of the keyboard. (*Above, right*) Data from input station is instantaneously summarized in card form by reproducing punch of output station located in control center. Output cards are machine-processed into reports which give a daily check on the in-plant status of all fabrication jobs.

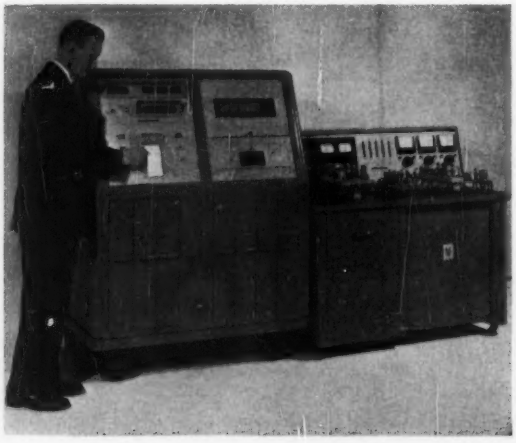
► Bank automation product line, series *1200* character-sensing equipment, is compatible with standard IBM data-processing systems to provide a full range of electronic paper check-handling systems for banks of various sizes. Key to the paper-handling equipment is the use of a "common language" in the form of Arabic characters printed in magnetic ink on each check, which can be read by both men and machines, and which meets specifications of the American Banking Association.

Instruments

▲ Impulse totalizing relays announced by the Westinghouse meter department for multiunit metering of power distribution systems use semiconductor devices to combine demand impulses from as many as seven sources and to retransmit them over a single output circuit. With the exception of one output relay, all circuit elements are static devices—transistors, silicon diodes, capacitors, and resistors. Equipment is compatible with existing systems without changes in input pulsing equipment of final impulse receiver.



▲ Hall-effect sensor, shown on ceramic mount. Developed by electrical engineers at the Armour Research Foundation of Illinois Institute of Technology, the sensor's small size (here shown with paper clip) makes it valuable in measuring radio interference in confined areas around communications equipment.

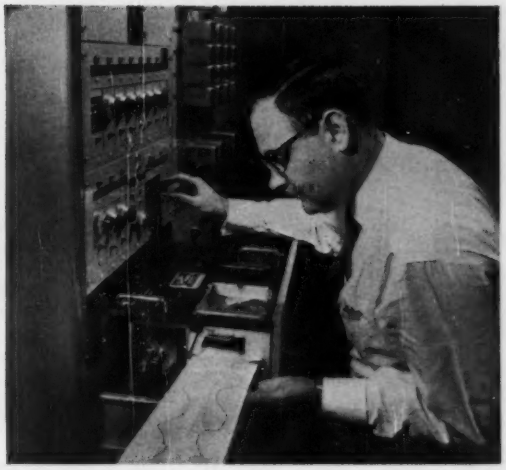


◄ SCATE (Stromberg-Carlson Automatic Test Equipment) is a flexible system which can be used to check complex electronic systems automatically and to pinpoint any faults which are discovered. Unit at the left is the basic SCATE controller-programmer, while unit at the right is an adapter which fits the SCATE system to a specific weapons system. Units on the counter of the adapter are electronic subassemblies which can be tested by the system.

▲ Combining magnetic amplifier and transistor circuitry, this Westinghouse all-static Limitemp indicating temperature controller monitors and controls temperatures within the range of 100 to 400 F. Power output is 5 watts at 24 volts d-c, a level suitable for driving high-power static amplifiers, auxiliary relays, and other industrial control equipment.

◄ Newly developed directional-coupler type power meter being calibrated to reference standard for international comparison of r-f power standards by the National Bureau of Standards.

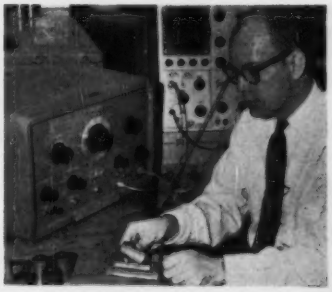
▲ Ammeter is calibrated on one of the new a-c calibration consoles made at the Weston Instruments Division of Daystrom, Inc. The a-c and d-c calibrators provide power source, circuitry, and control for rapid calibration of practically all types of portable, panel, switchboard, and recording-type instruments, with an accuracy of within 0.5 per cent of the indicated value.



▲ Electronic computer developed by Westinghouse engineers will analyze a residential dwelling and in 24 seconds determine the size of central air conditioner it needs. The unit is designed to consider over 50 factors influencing the indoor temperature of a house. The information is programmed into the machine through a set of dials and switches.

◄ By means of Videograph system, developed by Stanford Research Institute for A. B. Dick Co., pictures of moving trains can be made on railroad line, then flashed within seconds to central office or freight yard. Videograph is high-speed duplicator that uses television methods. (*Left, below*) When train passes, lights turn on automatically, and camera records image, relaying picture to distant print-out equipment.

► Secondary standard silicon solar cells, manufactured by the International Rectifier Corporation, provide accurate radiation measuring standards with which to check the efficiencies of production silicon solar cells.



▲ National Bureau of Standards has developed a nondestructive method for measuring true internal resistance of dry cells by applying a repetitive pulse. (*Right*) All-purpose package for metering the five basic types of single and polyphase distribution circuits, announced recently by the Westinghouse Electric Corporation.

▲ Hy-Com, communication system originated by GM Research Laboratories and developed by Delco Radio Division, broadcasts traffic information to passing motorists via a short-range 10- to 14-kc roadside transmitter and a receiver built into car radio or furnished as a self-contained hang-on unit. As car enters the controlled field of the transmitter's single-loop or ferrite-core antenna, the auxiliary receiver picks up the continuously repeated message by electromagnetic induction and turns on the set's transistorized output stage (in the case of the built-in unit) or momentarily interrupts the regular broadcast during the message interval. The system's localized field pattern enables all transmitters in a nation-wide highway network to operate on the same channel without interference). (*Right, above*) First extensive use of transistors in a 2-way mobile radio was achieved in this unit, which went into production at Motorola, Inc., Chicago, Ill., in April 1959. The MOTRAC radio has a completely transistorized power supply and receiver, and its transmitter is partially transistorized. The use of printed circuits, eyelet boards, and automatic soldering techniques in its production are new in the mobile radio field. For the user, the MOTRAC radio provides compactness and reliability, and most importantly, eliminates battery-drain problems.

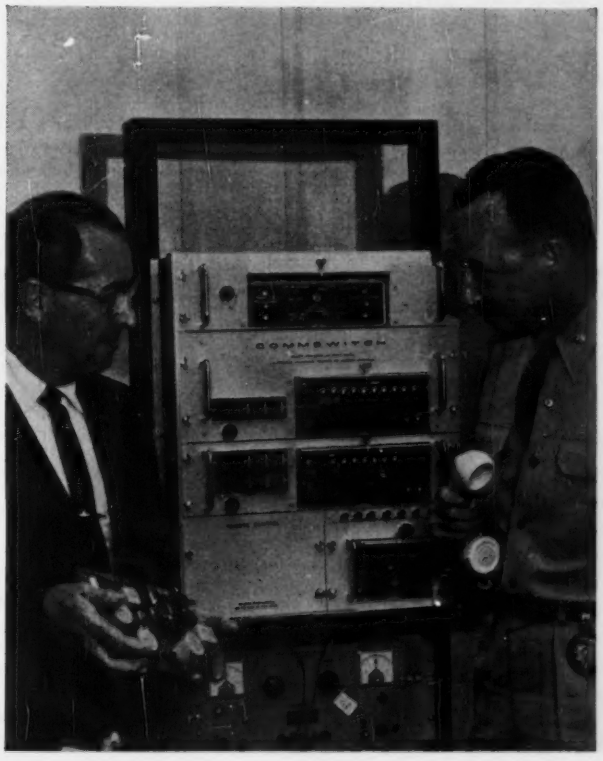
▲ Units of the IBM 7090 computer, nerve center of American Airlines' electronic reservations processing network, SABRE. It will use two of these transistorized computers in a single central location, linked by push buttons and leased lines to reservations and ticket offices in 61 cities. (*Left*) By pushing buttons, agent gets information pertaining to any American Airlines flight, including a complete record of each passenger's name, telephone number, and related data.

▲ A. W. Treptow and Lucille Finneran, Bell Telephone Laboratories, examine the screen printed pattern produced using a newly developed copper paste for circuits printed directly on ceramic bases. After drying, the printed ceramic "card" is fired in a 2-stage operation to burn off the printing vehicle, and to convert the copper oxide in the paste to metallic copper. The new method is advantageous in that it requires no adhesive to bond the copper pattern to the ceramic. Bond strengths are more than 2,000 pounds per square inch, and the bonds do not fail under dip-soldering conditions or during assembly operations. It is expected that the process will be competitive in cost with conventional printed wiring techniques.

▲ High-pressure autoclave used in the growing of synthetic quartz crystals for telephone communication purposes, shown at the Western Electric Company's Merrimack Valley Works, North Andover, Mass. R. A. Sullivan (*left*) holds large crystal grown in the large autoclave, while R. A. Laudise (*right*) holds smaller crystal and experimental vessel used at the Bell Telephone Laboratories in early research. Interest in growing quartz has resulted from the increasing difficulty in obtaining large crystals of natural quartz, and from the generally unstable market conditions.

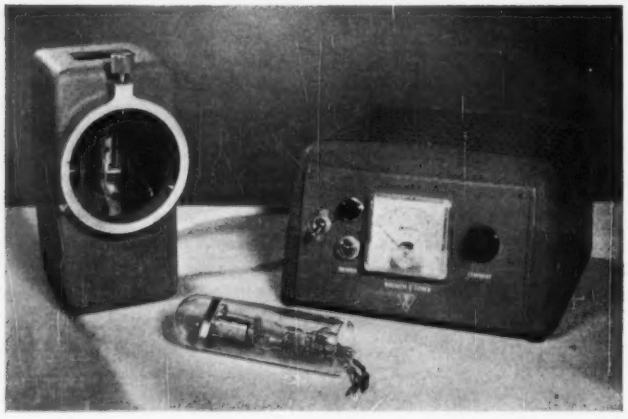
▲ TASI (Time Assignment Speech Interpolation), under development at Bell Telephone Laboratories, may double the number of conversations underseas telephone cables can carry. Here, in a final developmental model of part of TASI system, specialist tests group of printed wiring cards mounted in special holder. System will be made up of about 2,500 of these cards, mounted in such slide frames and inserted into slotted shelves of equipment bays.

► The Commswitch (for Communication Failure Detecting and Switching Equipment) listens to a telephone conversation, decides whether trouble along the line is making service unsatisfactory and, if so, instantly switches the call to an alternate line. In addition, the instrument, a development of the Kellogg Switchboard and Supply Company, prevents the injection of false information on the line, and even warns the operator of incipient trouble.

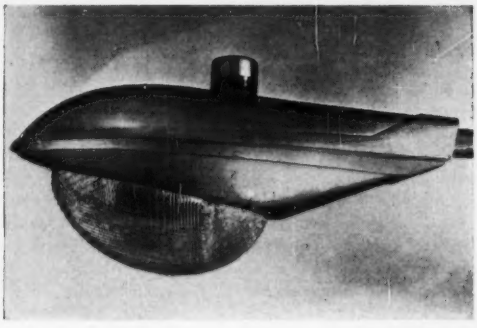


▲ Making an on-the-spot check of General Electric's low-angle fluorescent lighting system for the Manahawkin (N. J.) Causeway Bridge. The 42-inch luminaires are mounted at 2-foot intervals 50 inches above the roadway surface.

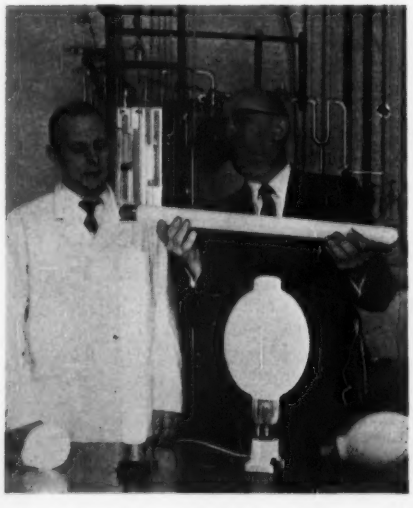
► Dashboards of 1960 Chrysler and Imperial automobiles are being illuminated by Sylvania "Panelescent" electroluminescent lamps. Model points to Panelescent lamp which will illuminate ignition key hole, compared with bulb type formerly used. Lamp creates light through excitation of phosphors placed in an electric field. New light source is cool to the touch and virtually unbreakable. It will outlast conventional incandescent bulbs approximately 10 to 1.



▲ Development of *HAK-50* air-cooled lamp by Sylvania Electric Products, Inc., has allowed the Bausch & Lomb Optical Company to redesign its hydrogen arc illuminator and eliminate the water cooling system. Results have been a valuable increase in light output and a steady d-c source for use with rotating sectors without introduction of harmful stroboscopic effects which may occur with tuned a-c amplifiers.

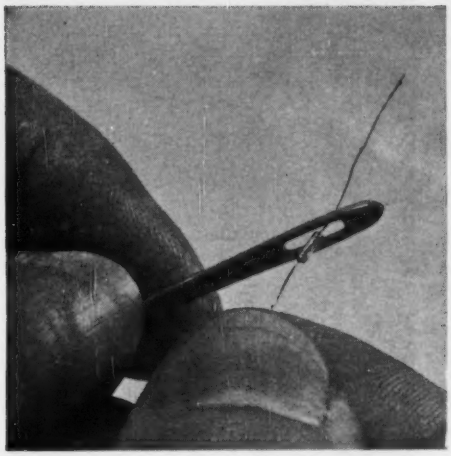


▲ The M-400 luminaire, a recent development of the General Electric Company, is part of an all-new line of mercury-vapor units which are now available. Featuring sleek, modern appearance, easier installation and maintenance, and increased lighting efficiency, this 400-watt unit is designed for use on heavily traveled streets and highways, as well as for downtown areas. The new cadmium sulfide photoelectric control is shown on the unit. This dusk-to-dawn control has a sensing element hermetically sealed in a special atmosphere for humidity protection and long life.

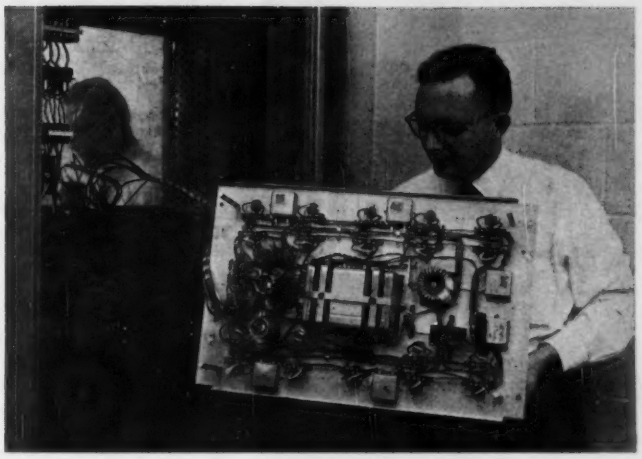


◄ Westinghouse fluorescent lamp requiring neither starter nor external ballast can be mounted in a single conventional screw base. A bimetallic starting switch is an integral part of the lamp. The need for an external ballast is eliminated by an incandescent filament within the lamp itself.

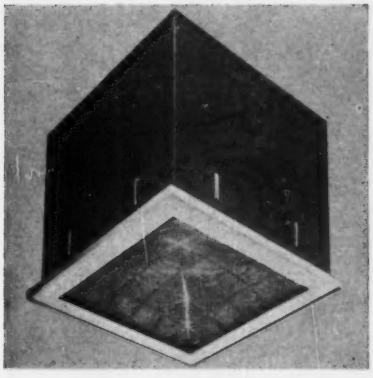
► Large, thin, rectangular glass plates developed by Westinghouse produce fluorescent light when an arc or electric discharge traverses the labyrinth sealed within the glass. The lamps are, in effect, a large area-source of light of good efficiency and light output.



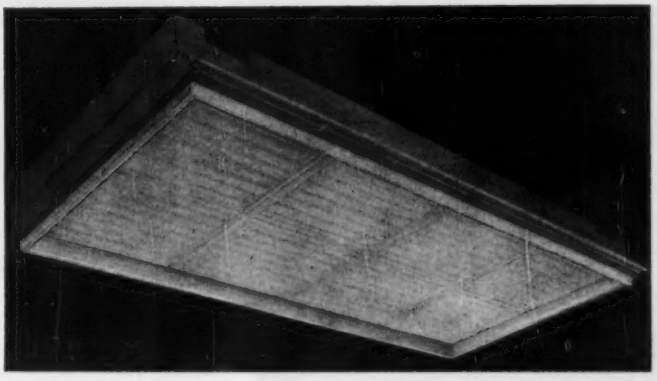
▲ Microminiature incandescent lamp, produced by Sylvania Electric Products, Inc., for use as a visual indicator in miniature transistor circuits, could also serve as a pilot light or illuminator.



▲ Cleveland Engineering Society's Engineering and Scientific Center is now operating a high-frequency lighting system developed by Westinghouse. Static converter supplies 1,500-cycle power to 26 fluorescent fixtures installed in some of the Center's conference rooms.

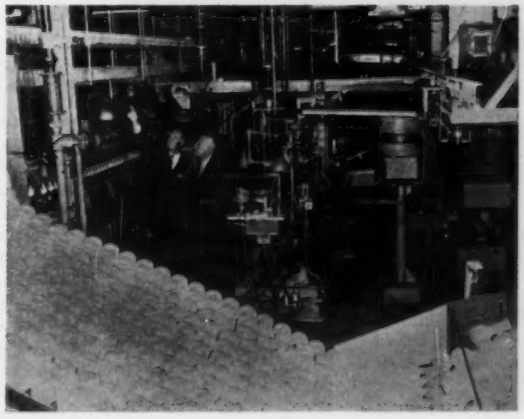


▲ Holophane Company, Inc., has announced the new *F-1565* series, a recessed luminaire for 12-inch tile construction, which features positive automatic latching. The lamp can be serviced from the floor with a standard lamp-changer pole.



▲ High efficiency, attractive appearance, freedom from glare, and uniform illumination on wide spacings are features of the Holophane Company's recently announced 6400 line of 2-foot-wide recessed fluorescent luminaires. Lighting levels ranging from 50 to 500 foot-candles are readily obtained through choice of 2-, 3-, or 4-lamp fixtures.

◄ "Panelescent" night light, designed as a home safety aid, is being made and marketed by Sylvania. The electroluminescent lighting device will operate day and night for 5 years at a cost of 1 cent per year for electric power.

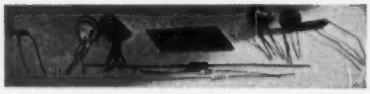


► Westinghouse is now operating a 100-foot-long lamp-making machine capable of producing 32 million lamps per year. It represents complete automation in the manufacture of incandescent lamps. F. M. Sloan, left, vice-president and manager of the company's lamp division and William Alvin, a retired employee, are shown as they examine the machine.

◄ Mock-up of satellite designed to convert sun's rays to electric energy is examined under simulated solar heat conditions at ITT Laboratories. Special ceramic coating on space vehicle's exterior provides high a-c potentials to operate equipment within the satellite. Unlike present "solar batteries," the new development relies on temperature changes alone, rather than light energy.

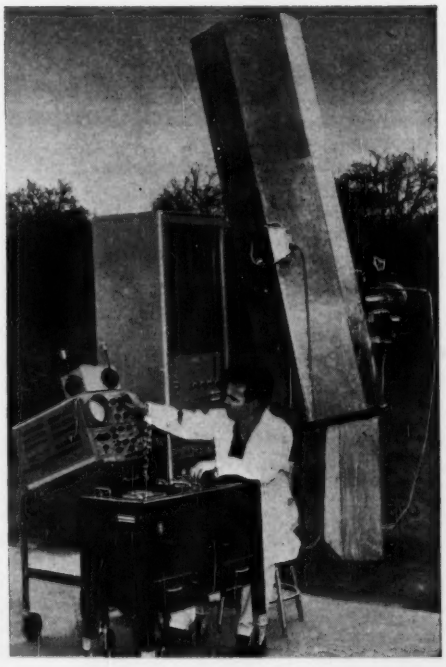
► Minneapolis-Honeywell scientist uses microscope to examine rotating beryllium sphere machined to tolerances finer than 15×10^{-6} inch to form rotor of electrically suspended gyroscope. Gyro rotor spins at high speeds unassisted for long periods of time and is virtually friction-free.

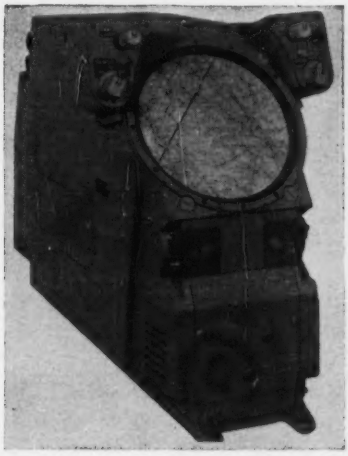
► Minute slice of silicon crystal, produced by Westinghouse, can be used as a light-sensing device for a satellite telemetry system. It will perform all the functions of its best commercially available counterpart—a miniaturized, transistorized oscillator, the components of which are shown below—but will be vastly more reliable because of the simplicity of its structure.



◄ Atlas intercontinental ballistic missile is raised into firing position by new erector launcher mechanism. The mechanism's control system, developed by Westinghouse and Convair, makes it possible to store the missile horizontally and erect it to a firing position in 2 minutes at the push of a single button.

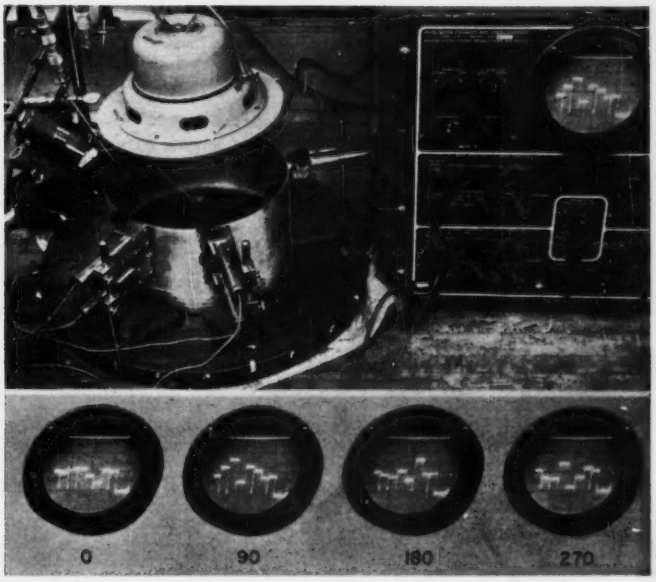
► Infrared satellite tracker, developed by ITT Laboratories, tracks artificial satellites by faint "heat waves" they emit as they travel across the sky. Reflector system within upright tube focuses radiation from satellite onto detector cell mounted midway up tube. Trace is shown on oscilloscope and registered by the recorder.





◄ This navigational device enables an interceptor pilot to follow a mission pictorially with the aid of small symbols on the viewing screen which continuously indicate the interceptor's and target's position and movement. Heading to target, flying range with existing fuel supply and distance to base are also shown. Device was a joint project of U. S. Army and Hughes Aircraft Co.

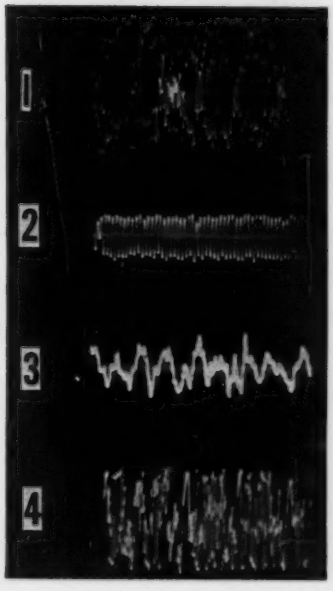
► Army helicopter pulls away with new cable package that can pay out 10 miles of telephone line overland at 100 miles an hour. Cable carries up to 96 simultaneous voice conversations. System, developed jointly by U. S. Army and ITT, adds new speed and versatility to United States combat forces.



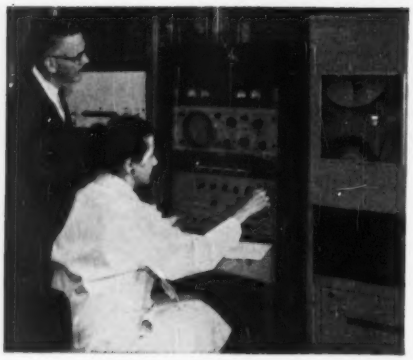
◄ A time-saving vibration analyzer of the National Bureau of Standards. Analyzer can be used for determining vibration characteristics of bodies such as aircraft and missile structures. Instrument uses principle of a stroboscope, and enables operator to explore the vibration patterns quickly in a complex structure. Bell-shaped object is a loudspeaker vibrating cylinder below it. Horizontal traces are displayed showing relative amplitude of signals from pickups mounted next to the cylinder wall.

Courtesy Stromberg-Carlson

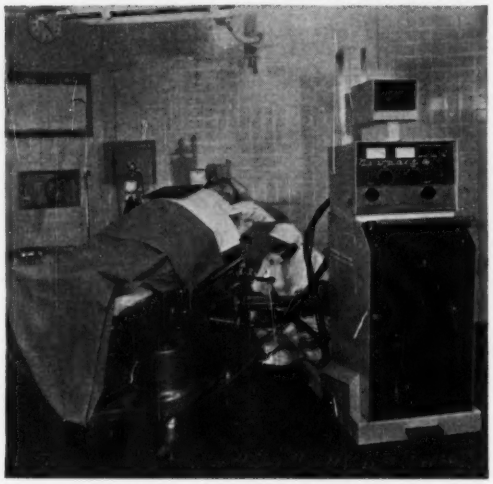
◄ Big 600-watt loudspeaker being placed in reverberation chamber which is used for testing electronic components in an environment of high-sound pressures.



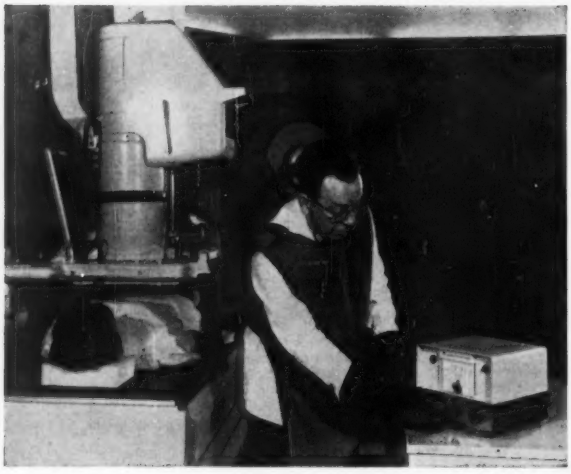
► U. S. Army radar separates target images of (1) train, (2) auto, (3) walking man, (4) walking girl. Target signals are also audible with earphones. Hazeltine Corp. is producing these radar sets for Army.



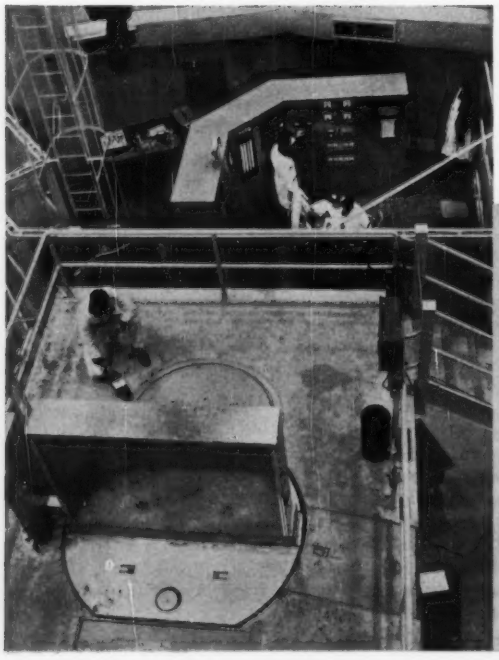
◄ Method developed by National Bureau of Standards makes use of magnetic tape to record heartbeat data and a high-speed digital computer to compare these records. Method helps physician to make an objective diagnosis of a patient.



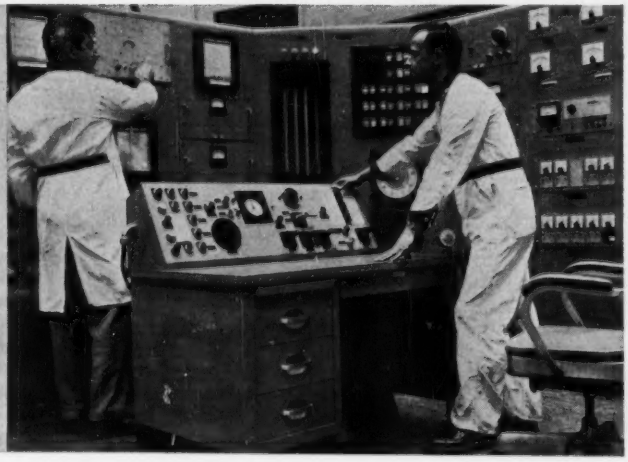
▲ Air-flow pressurizing system developed by Westinghouse makes this mobile X-ray unit explosion-safe for operating-room use. Air used to pressurize system is taken from above the 5-foot level—a zone free from explosive gases—and pumped into sealed unit to prevent explosive anesthetic gases, which are heavier than air, from entering the unit.

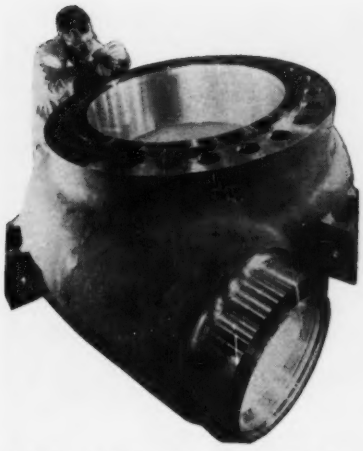


◄ Monitor for instantaneous measurement of the integrated maximum radiation dose to a patient during all types of fluoroscopy was announced by Westinghouse. The "Radometer" monitor consists of a small-volume air ionization chamber, installed between the fluoroscopic X-ray tube and the cone in the table, and a recording instrument, which can be positioned either in the room or at the fluoroscopic control.

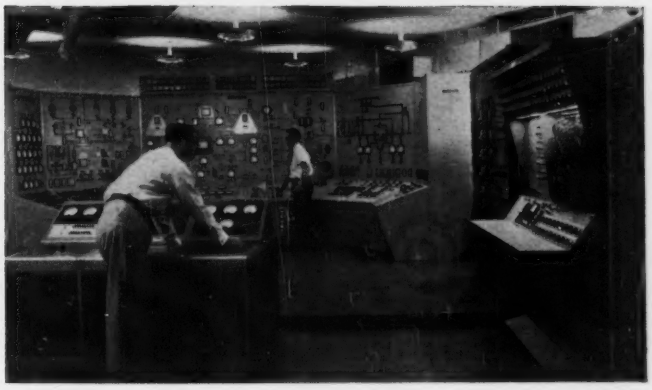


◄ Overhead view from inside Brookhaven National Laboratory's Medical Research Reactor. In the foreground, health physicist is shown checking the radioactivity level on top of the reactor itself. (*Below*) Control console, in foreground, and instrument panel, at the rear, for the Medical Research Reactor.

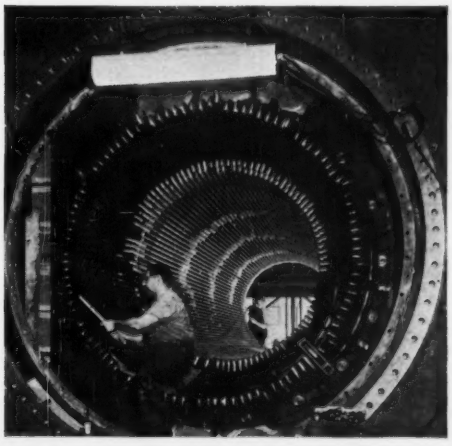




▲ This 46,000-pound canned motor pump is being made by Westinghouse for Yankee Atomic Electric Company's 134,000-kw nuclear power plant. Finished pump will be over 11 feet high and weigh 39,000 pounds.



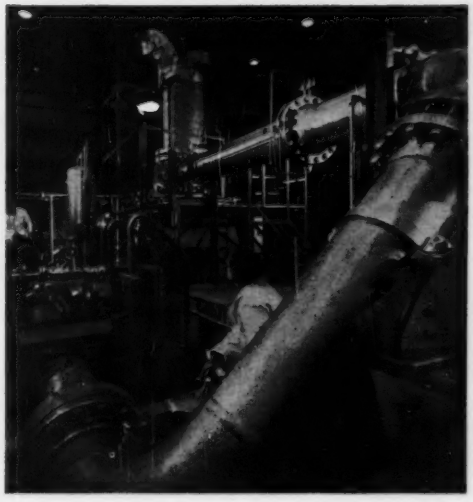
▲ Training simulator that responds exactly as does an atomic propulsion plant will be used in training officers of the nuclear-powered merchant ship, *N. S. Savannah*. Designed and constructed by Westinghouse under contract to the Maritime Administration, it contains an analog computer as a central element. The system is installed in a classroom building at Lynchburg (Va.) College, where training is being conducted by the Babcock & Wilcox Company, which is designing, building, and supplying the nuclear propulsion system for the *Savannah*.



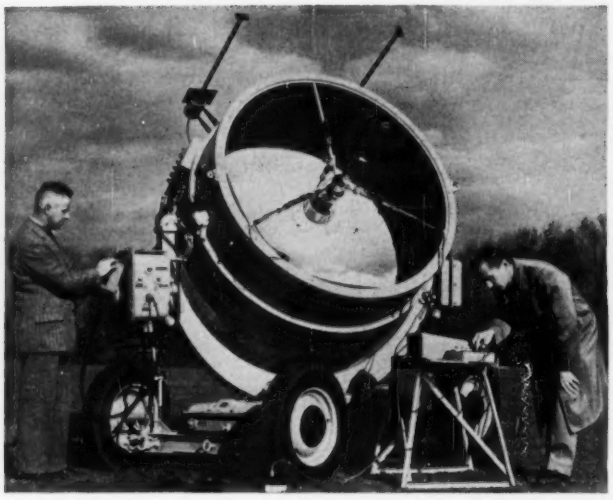
◀ Skilled workmen at the General Electric Company install windings in the huge stator which will house the generator rotor for the steam turbine–generator to be installed in Commonwealth Edison Company's 180,000-kw Dresden Nuclear Power Station near Chicago, Ill., scheduled for completion during 1960. Steam to drive the turbine–generator will be made by a dual-cycle boiling water reactor being built by the General Electric Atomic Power Equipment Department at San Jose, Calif.

▼ Engineers at Westinghouse's atomic equipment department have recently built a "twin-loop" test facility for canned motor pumps (*center, background*) designed for controlled circulation boiler applications. Fluids at temperatures up to 500 F can be pumped through the new unit, which supplements existing high-temperature 2,000-psi test loops.

◀ Being readied for shipment to the Westinghouse Reactor Evaluation Center at Waltz Mill, Pa., is one of 40 fuel elements designed and built by Westinghouse for use in Belgium's first atomic power plant. When the reactor core is completed, it will consist of 32 fuel elements, each with a total of 110 tubes containing pellets of uranium oxide, the nuclear fuel for the reactor. The remaining eight elements will be used as spares.

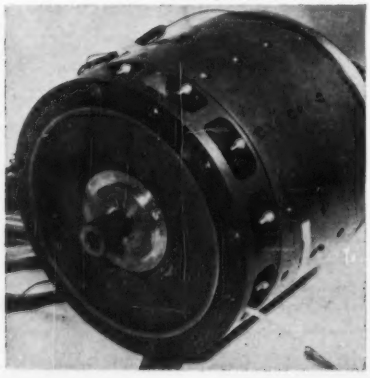


▲ Scale model of a satellite containing new gallium arsenite solar battery and tunnel diode developed by RCA Laboratories at the David Sarnoff Research Center, Princeton, N. J. Devices are mounted under transparent shell at top of the model.



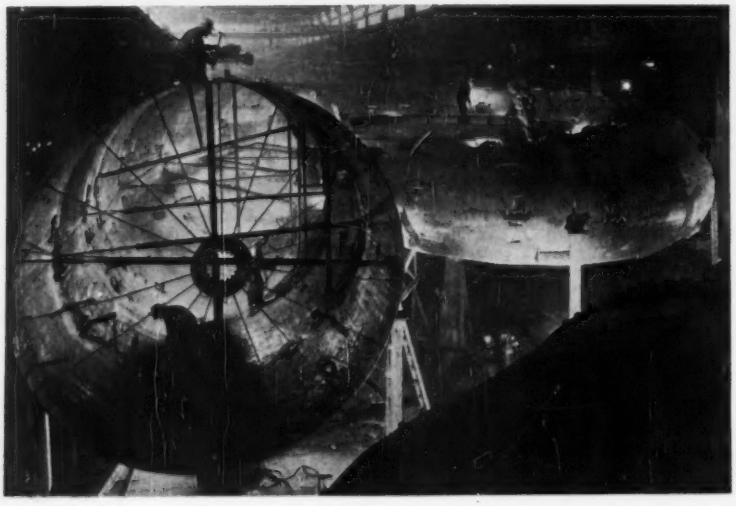
▲ A compact electron tube device that converts solar heat directly to watts of electric power and employs no moving parts has been developed by RCA in a research program that may lead to new power sources for missiles, space vehicles, and remote areas. The device, known as a thermionic generator, is shown being tested in a solar furnace.

Courtesy Jack & Heints, Inc.



◄ View of a new type brushless a-c generator, called Secsyn, which does not require rotating rectifiers. Secsyn shown uses a spider magnetically polarized in one direction and a tube having sections magnetically polarized in the other direction. Exciting coils are placed at either end of the machine such that the magnetic circuit is symmetrical about a plane perpendicular to the shaft passing through the center of the stack.

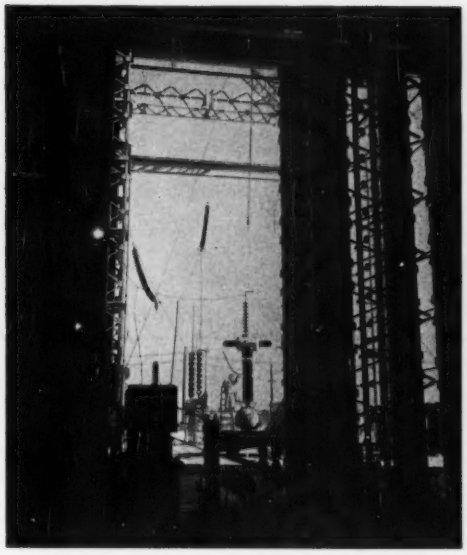
▲ This 27-foot diameter waterwheel generator half "spider" is being welded at Westinghouse. When finished, the 25-ton piece will be joined with its matching half for installation in one of the 13 167,000-kva waterwheel generators for the $720 million New York State Power Authority's Niagara Power Project.



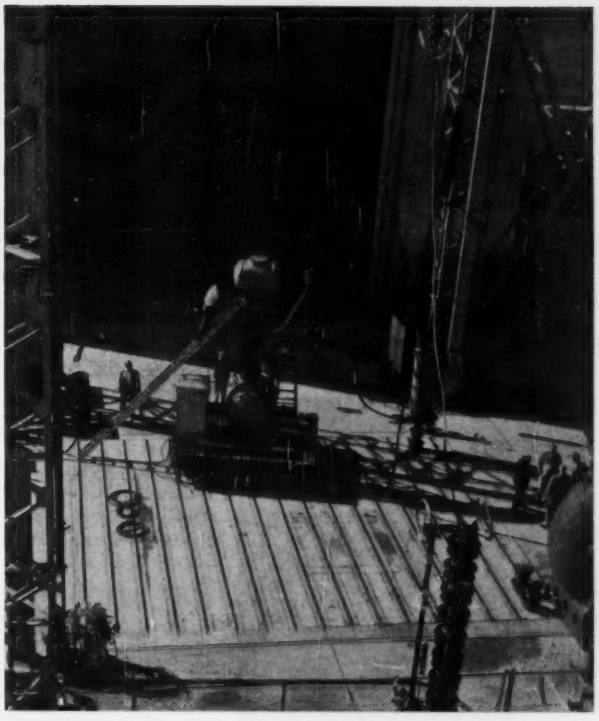
◄ Shop assembly of huge scroll case and stay ring for one of 12 reversible pump-turbines for the Tuscarora Project, Power Authority of the State of New York. As pumps, units will deliver 3,400 cfs against an 85-foot head; as turbines, each is rated 28,000 hp under 75 feet of head.

Courtesy Allis Chalmers

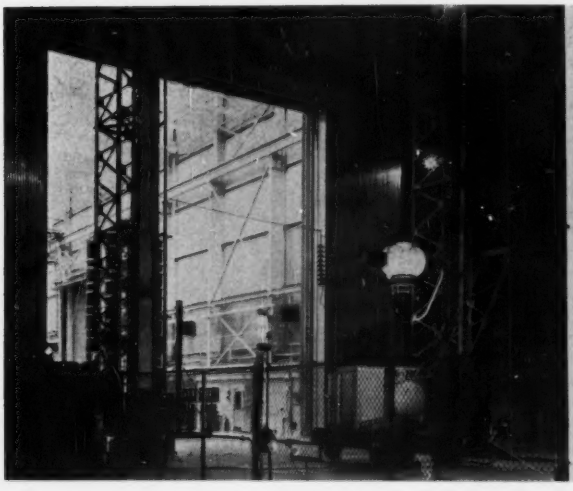
High-Voltage Switchgear Tests



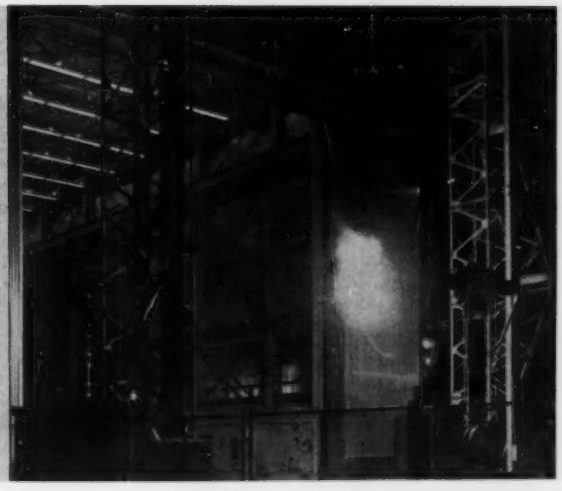
▲ A million-dollar high-voltage testing laboratory, shown in the photographs on this page, has been opened by the General Electric Company in Philadelphia, Pa. It is capable of generating up to 3 million volts for impulse testing and 1 million volts for indoor and outdoor tests. Here a potential of 3 million volts stands ready for test use in impulse generator. Through open door in background workman readies air-blast circuit breaker for outdoor test run.



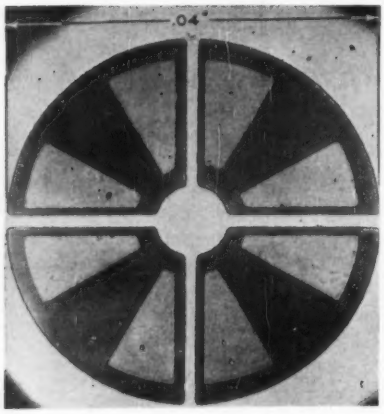
► Workmen prepare air-blast circuit breaker for tests employing man-made lightning. Control equipment enables engineers to direct current at superhigh voltages to breaker under test at precise intervals.



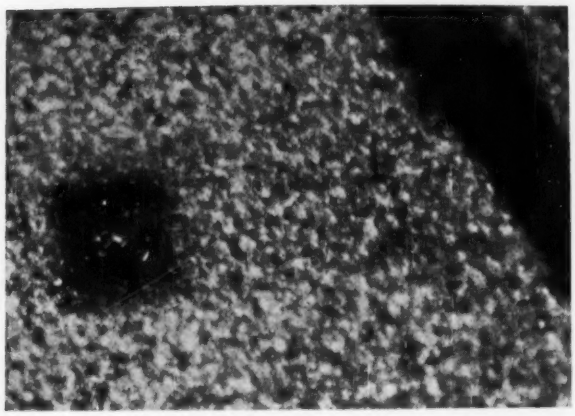
▲ Night test scene at General Electric's high-voltage switchgear testing laboratory. An air-blast breaker, shown mounted on a test car at the right, is about to be hit with a jolt from the impulse generator, which is visible inside the doors at left center.



▲ Brilliant light is generated as impulse arc flashes over insulator string right after breaker under test interrupts power fault. Investigations have shown air-blast breakers less susceptible to damaging effects of follow-up lightning surges than are other designs.



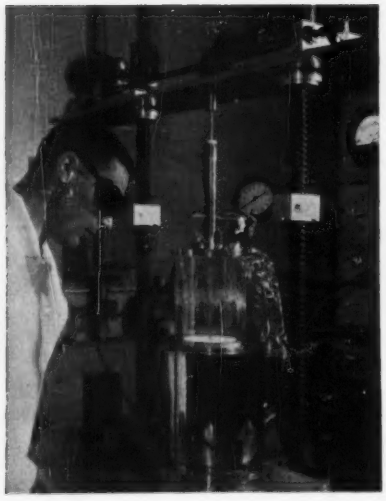
▲ Top view of Bell Telephone Laboratories' stepping transistor structure, as fabricated on a single piece of silicon by oxide masking diffusion techniques. Light and dark areas show the different electrically active regions of the stepping transistor structure.



▲ Seen under a microscope, an experimental tunnel diode developed at RCA's David Sarnoff Research Center is dwarfed by a single strand of human hair. The tunnel diode consists of a dot of semiconductor material, such as germanium or gallium arsenide, only 0.003 inch in diameter on a base that is only slightly larger. The experimental device shows bright promise as an ultraminiature basic circuit element.

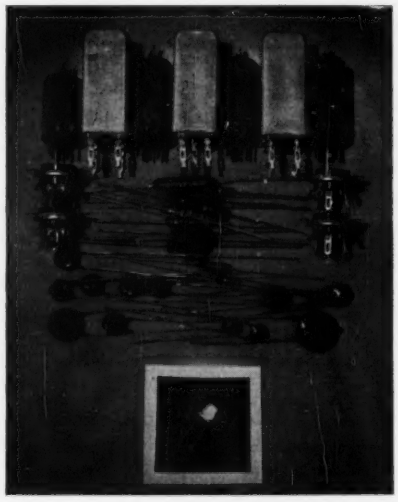
◄ Westinghouse high-power silicon transistors, when operated as a switch, are capable of controlling over 5 kw of power. They have the following characteristics: collector-to-emitter voltage ratings from 30 to 200 volts; maximum operating junction temperature of 150 C; and saturation resistance of less than 0.1 ohm. With a minimum current gain of 10- to 15-amperes collector current, these devices have a maximum collector current rating of 30 amperes. Because of the higher temperature capabilities of silicon, one of these transistors can be used in applications that previously required a number of germanium units in parallel.

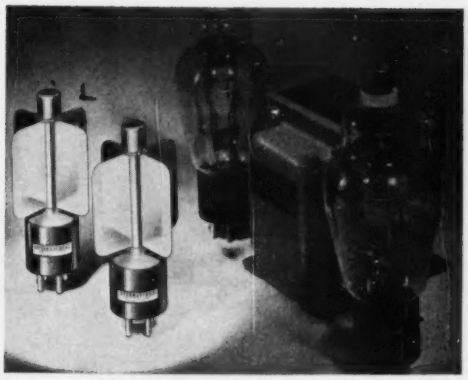
▲ Trinistor triode—a 3-terminal multijunction silicon n-p-n-p switch whose breakover voltage can be controlled by the base current—was announced by Westinghouse in peak-inverse-voltage ratings up to 400 volts. It is suited to applications in circuits in place of thyratrons.



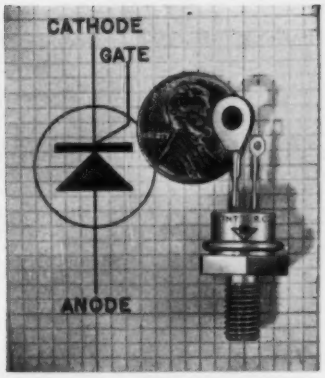
◄ Silicon carbide crystals for use in high-temperature semiconductors are produced from this modified version of a standard crystal-pulling furnace at Stanford Research Institute.

► Progress in the development of practical tunnel diode devices has been announced by the General Electric Research Laboratory. If an FM receiver were rebuilt using a tunnel diode (in can, at bottom of photo), all the conventional components shown could be omitted, although with some sacrifices in performance. Such performance limitations reflect the present state of the art and not the inherent capabilities of the diode.

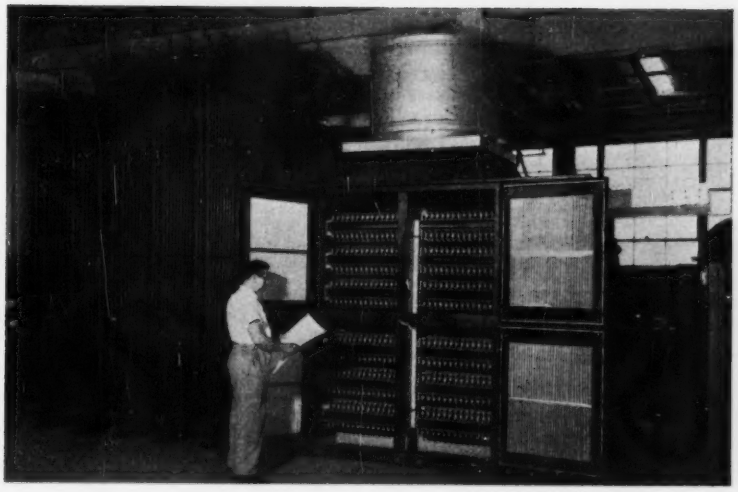




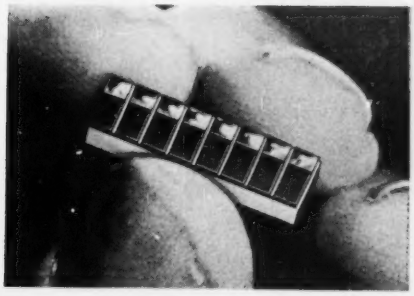
◄ Designed to replace type 866 mercury-vapor rectifier tubes, as well as the space-consuming filament transformer necessary to tube action, as shown, high-voltage silicon cartridges manufactured by International Rectifier Corporation provide 2/3 reduction in space and weigh less than 1/16 of equivalent tube circuitry.



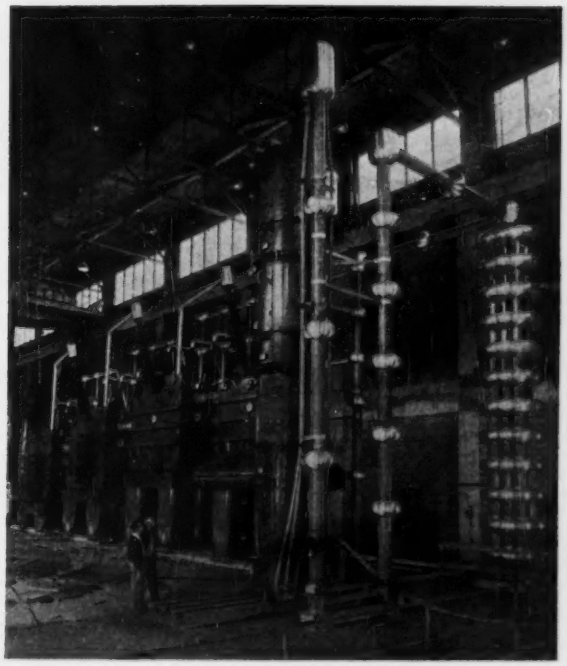
▲ A silicon control rectifier, combining some of the characteristics of the rectifier and power transistor, has been announced by International Rectifier Corp. It can switch rapidly to a conducting state either when a signal is applied to its third (gate) terminal, or when its critical forward breakover voltage is exceeded.



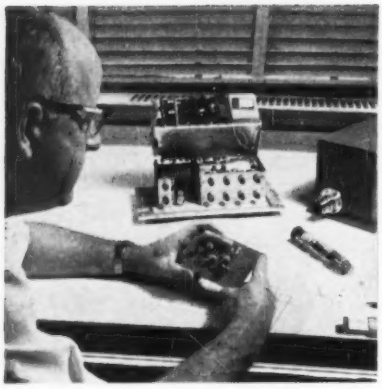
◄ Silicon rectifier, built by I-T-E Circuit Breaker Company, will supply 3,500 kw for classified research work at University of California Los Alamos Scientific Laboratory. It comprises four 125-volt rectifier sections that can be connected in series-parallel combinations to supply full power at 500, 250, and 125 volts.



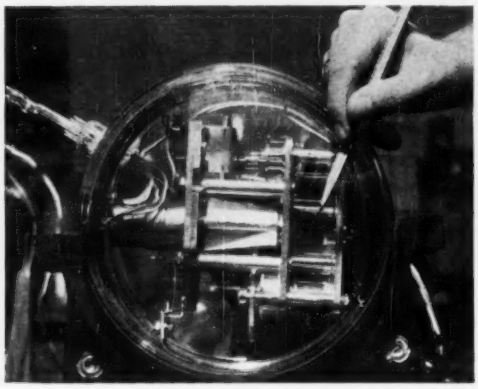
▲ Silicon photovoltaic readout matrices feature response times of about 10 microseconds. Developed by International Rectifier Corp., they convert light energy directly into electricity, with no need for external power supplies.



► This 600,000-volt Allis-Chalmers automatic voltage regulated silicon rectifier, built for the Union Carbide Nuclear Corporation, has a maximum current rating of 2 amperes. Output voltage can be adjusted in 256 steps from 6% to 100%. It consists of four 150-kv 3-phase bridge rectifiers in cascade with 500 silicon diodes in series in each arm.

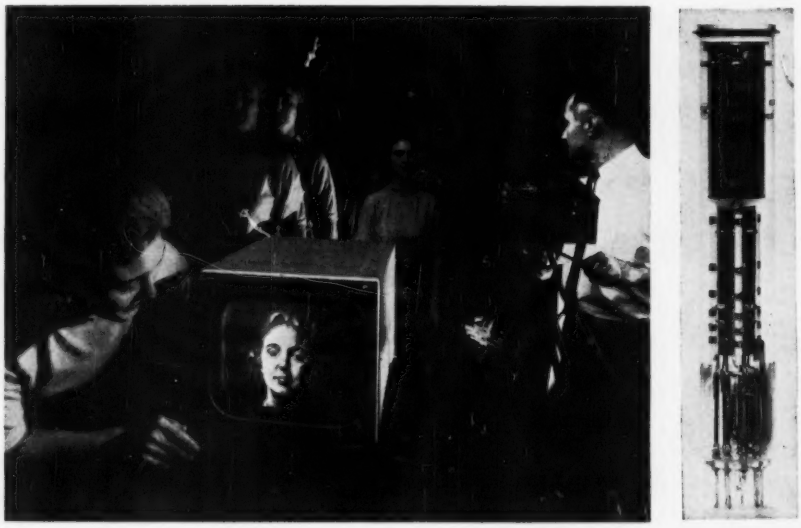


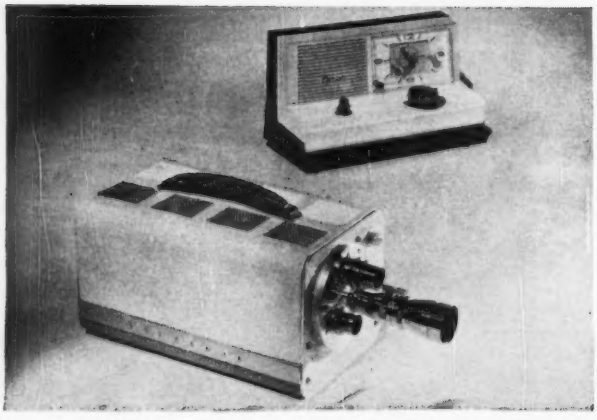
▲ Special television system that will permit astronomers on the ground to aim and focus telescope suspended from balloon 15 miles up is being developed at RCA Laboratories for Princeton University in an experiment sponsored by the National Science Foundation and the Office of Naval Research.



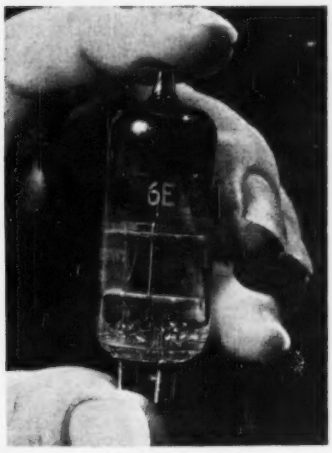
▲ Face of radically new and simple electronic camera under development at RCA's Astro-Electronic Products Division for utilization in satellites and space vehicles. The device is potentially capable of taking continuous strips of photographs of clouds which are around the earth or of the moon's surface for transmission to the ground by means of television techniques.

► The Westinghouse "Permachon" tube, shown at extreme right, is an electronic pick-up and storage tube that can operate in a standard vidicon camera and permits a scene perceived by it to be stored on the target screen and continuously scanned and displayed over a 30-minute period. If the target is not scanned, the information is lost. The target can retain information accurately after exposures as brief as 23 microseconds.

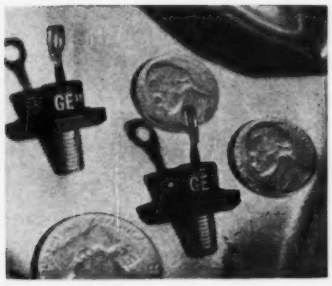




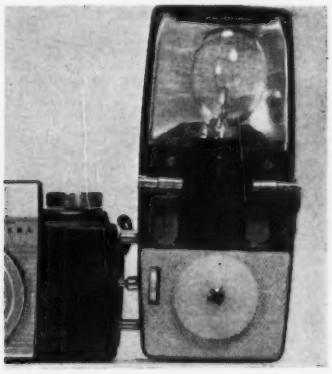
◄ Sylvania Electric Products, Inc., is marketing a closed-circuit television system designed to stimulate greater use of the medium in schools, industry, and commerce. The camera, priced well below most custom-designed systems currently on the market, is shown in comparison with a clock radio. The vidicon-type camera weighs only 15 pounds, requires no special lighting, and will transmit an image on channels 2 through 6 to any standard home-type receiver. It is equipped with a turret mount for three different lenses, but is available with one, two, or three lenses, as required.



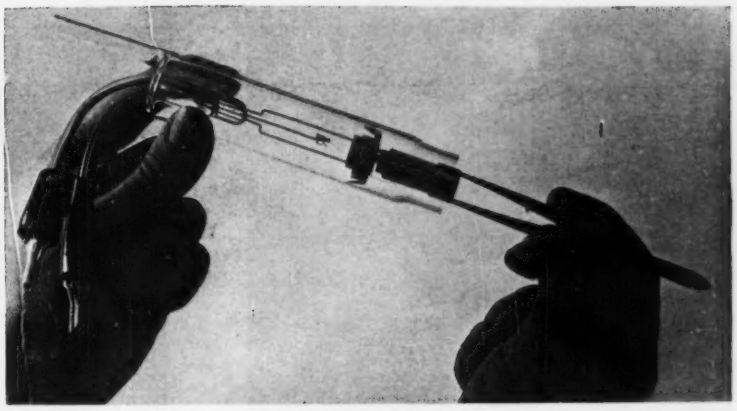
▲ High-frequency sharp-cutoff *6EV5* Westinghouse tetrode tube is for use as the r-f amplifier in vhf television tuners. It also is well suited for use in i-f amplifiers and other vhf applications.



▲ Fourteen new silicon stud-mount medium-current rectifiers—seven conventional types with the stud as the cathode and seven reverse-current types with the stud as the anode—have been announced by General Electric.

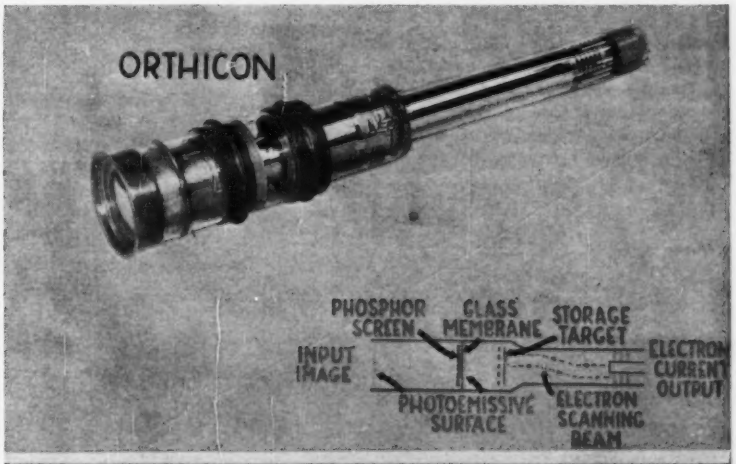


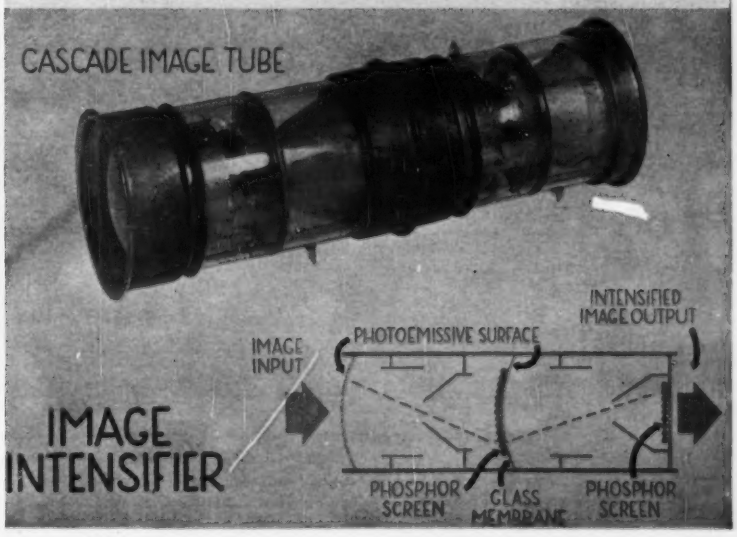
▲ A quick half-turn on the wheel of this Eastman Kodak Company flash-holder charges an electrolytic 125-μf 35-volt d-c capacitor enough to flash M-2 (Midget), no. 5, or no. 25 bulbs.



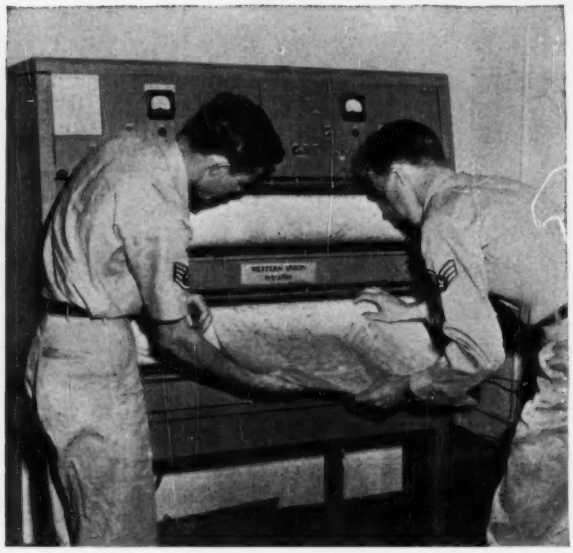
▲ Experimental electron tube, under development at Westinghouse, gets its supply of electrons from a tiny crystal of silicon carbide, no larger than the head of a pin. Crystal replaces the hot, power-consuming cathode usually found in electronic tubes. The tube depends upon a new form of electron emission discovered in silicon carbide.

▼ The Army Corps of Engineers has procured from RCA two image-intensifier tubes. Cascade tube is the heart of direct-viewing image-intensifier telescopes, which produce clear, bright images of distant scenes illuminated solely by the light from moon and stars. Orthicon tube produces pictures on a monitor under similar illumination.





▲ Users of Western Union Telex now can dial correspondents 24 hours a day for instant, automatic 2-way telegraphic communication either long distance or locally. No intervening manual operation is involved. When a key is pressed, the machine prints the name and city of the other subscriber automatically, assuring a correct connection.



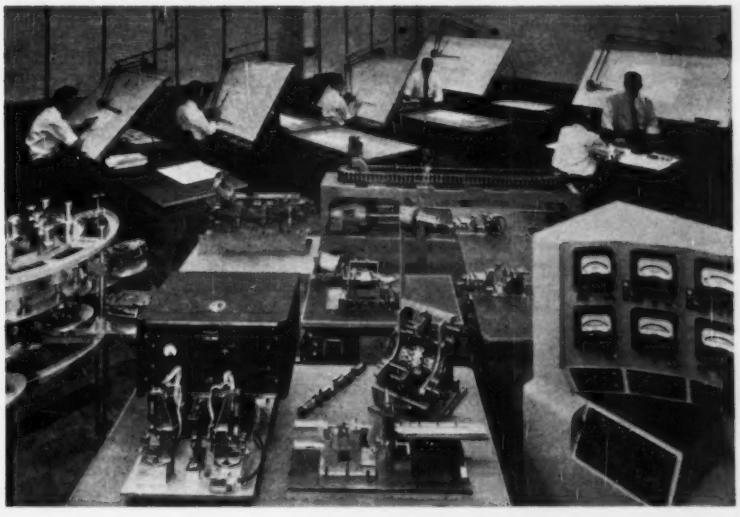
▲ At Barksdale Air Force Base, a special tropopause chart is placed on Western Union facsimile machine for transmission to weather station network served by central transmitting station at Barksdale. The new system, known as Strategic Facsimile Network, links 57 Air Force weather stations throughout the United States to provide high-altitude weather data at speeds double those employed previously. Charts and maps 18 by 36 inches can be transmitted in 30 minutes or less.

▲ Seven seconds after odd-lot orders are executed at the New York Stock Exchange, confirmations transmitted from the Exchange floor by Western Union Brokerfax arrive in the order room of Merrill Lynch, Pierce, Fenner & Smith, several blocks away. These facsimiles of the executed orders are received and sent to operators to be telegraphed to originating branches.

▲ Department store warehouse employee receives shipping order, sent directly from sales floor, in facsimile "picture" form on Western Union's letter-size Intrafax. Machine at right is transmitting report of shipments to accounting department. Recorder is at the left.

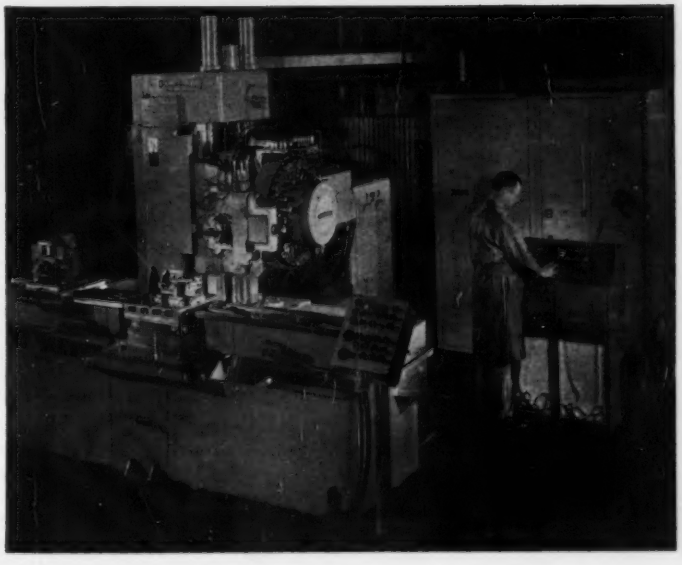
◄ Milling machine cuts out metal part under the APT (automatically programmed tool) System developed by the Servomechanisms Laboratory of the Massachusetts Institute of Technology. Clarence Feldmann, left, research assistant, and Gordon Phinney, machinist, have no need to check the machine as it follows its course, which was automatically planned by a digital computer.

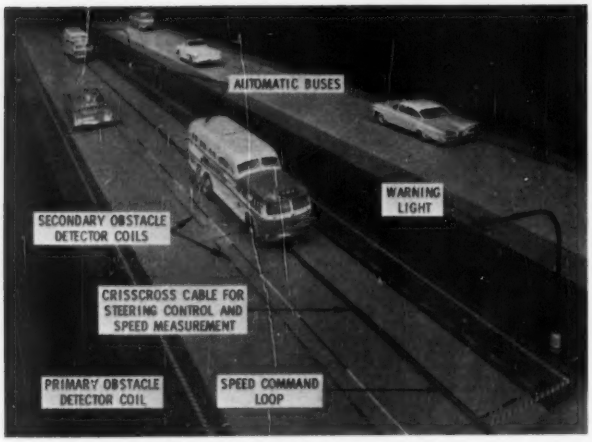
► C. L. Young, drafting specialist, operates General Electric's Autoprogrammer. Using half-scale dimensionless drawings, the unit automatically produces the punched tape used in General Electric's Mark III numerical positioning control on 100-ton Wiedematic turret punch press.



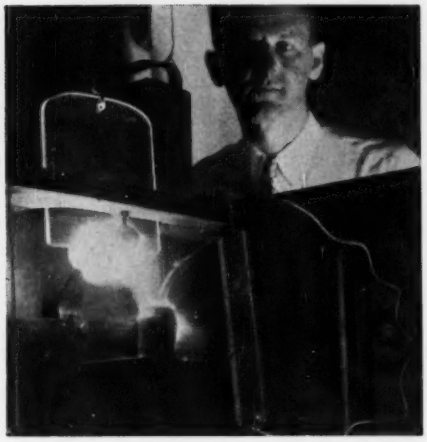
◄ Large array of ingenious, money-saving machines for the production of electron tubes and semiconductors has been designed and built by the equipment development laboratories of CBS Electronics, a Division of the Columbia Broadcasting System, Inc., at Danvers, Mass.

► The Milwaukee-Matic, a versatile, automatic tool-changing, tape-controlled combination machine that makes automation economically feasible for small-lot manufacturers has been developed by Kearney & Trecker Corporation, with General Electric Company supplying the controls. The machine, which performs milling, drilling, reaming, tapping, and boring operations, reduces setup time, production time, labor costs, and inventory.

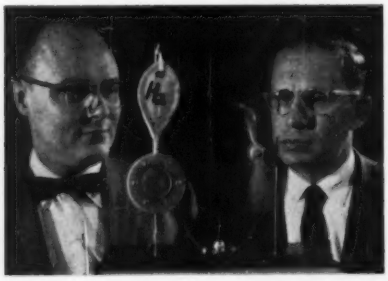




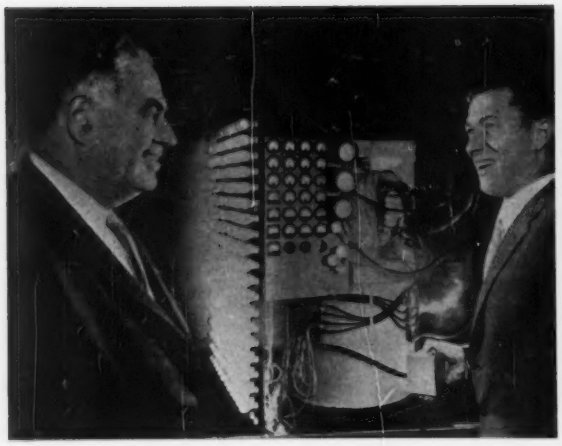
▲ Although only a 1/40 scale model, this miniature highway of the future developed by GM Research Laboratories and AR&T Electronics, Inc., contains all the electronics needed for complete automatic control of full-size vehicles. Cars tracking the electromagnetic field surrounding a 50-kc crisscross cable imbedded in the automatic lane sense their own speed by the number of "nulls" passed per second and automatically adjust to the highway speed command by a separate, modulated 90-kc wire.



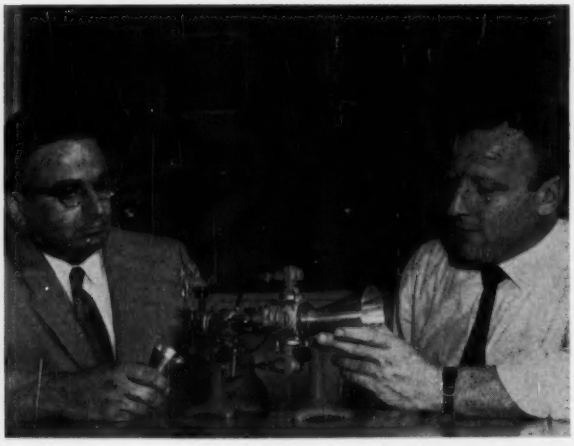
▲ Flash of man-made lightning triggers an underwater explosion that bulges an aluminum tube with a force equivalent to 6,000 hp. The experimental device, developed by Republic Aviation Corporation, sets off the explosion by passing electricity through the water, converting the resulting shock wave into the force required to shape metals.



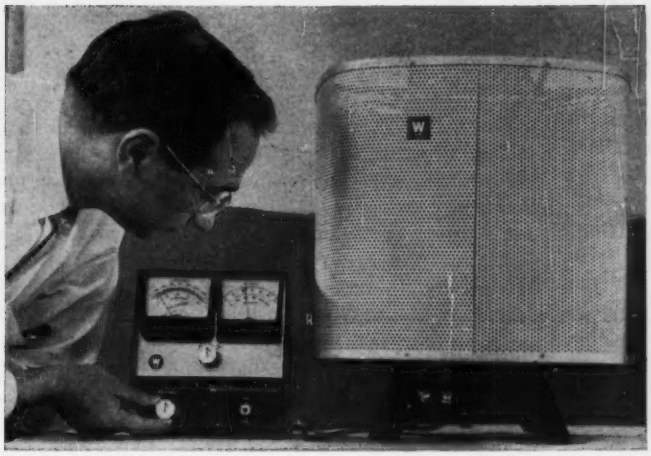
◀ Fuel cell, producing electricity directly from gaseous fuel, is demonstrated by General Electric Research Laboratory scientists. Dr. L. W. Niedrach, left, and Dr W. T. Grubb, who are responsible for the device, look on as the electricity generated in the small plastic cell spins a miniature propeller. Fuel in this case is hydrogen, contained in the balloon marked "H_2." The hydrogen reacts with the oxygen in the air to produce electricity and, as a by-product, water.



▲ Dr. Arthur Kantrowitz, left, and Dr. R. J. Rosa view Avco-Everett Research Laboratory's experimental magnetohydrodynamic (MHD) power generator as it successfully lights a 228-lamp bank of 50-watt bulbs. The device, which is capable of a more than 10,000-watt output, represents a first step in application of the MHD theory to generation of commercial electric power.



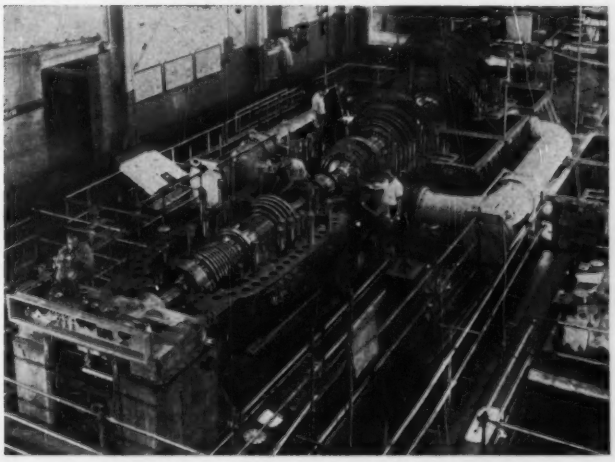
▲ P. J. Allen, left, and R. D. Tompkins examine X-band instantaneous microwave polarimeter developed at U. S. Naval Research Laboratory. Incoming signals, resolved into linear polarized components, are converted to i-f signals by mixing with local oscillator signal in precision trimode turnstile mixer. Applied to cathode-ray tube, i-f signals generate patterns, permitting direct observation of polarization phenomena.

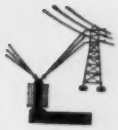


▲ A 100-watt thermoelectric generator known as *TAP-100*, one of the most powerful devices of its kind ever built, was developed by Westinghouse for ARDC. About the size of a medicine ball and weighing 40 pounds, it delivers three times as much power per pound of weight as most previously announced generators.

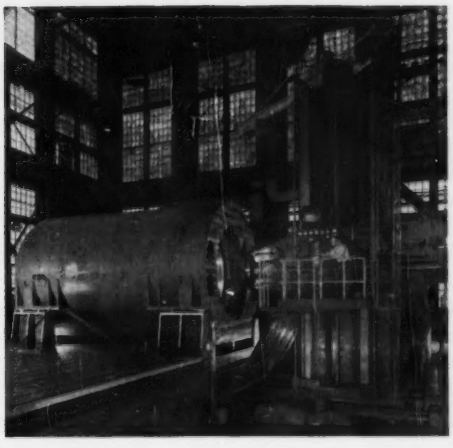
▲ This 3-phase testing reactor of more than 300,000 kva at Westinghouse studies thermal and electrical characteristics of modern high-capacity turbine-generators. Reactor can test turbine-generators over 400,000 kva at certain voltages.

► View of a triple-flow tandem steam turbine being assembled in a large turbine test pit at the Allis Chalmers Manufacturing Company.





Courtesy Consolidated Diesel Electric Corp.



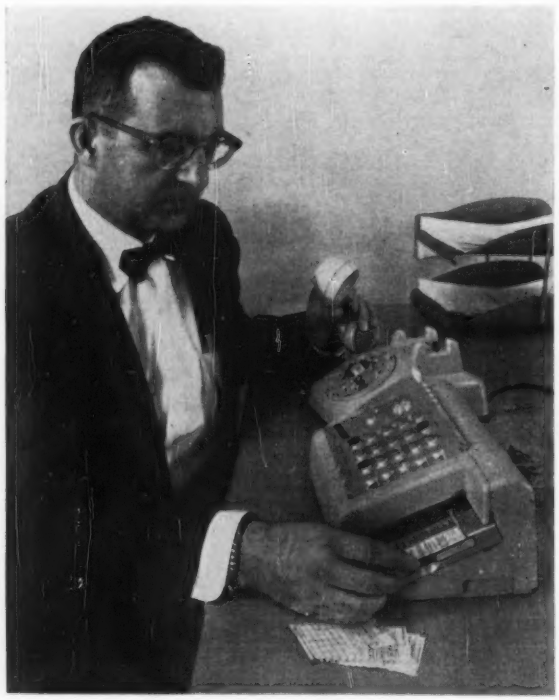
◄ 200-ton Ingersoll 8-inch milling and boring machine works on stator for one of four fully supercharged hydrogen-cooled, 176,470-kva generators for 150,000-kw steam turbine-generator units for a new power station.

► The U.S. Army's "Uninterrupted Power Supply Unit" that provides a standby power source for vital nuclear power equipment at Fort Belvoir, Va.

(Continued from page 1)

a talk-back arrangement allowing students in any one of 36 classrooms to communicate with the instructor at the television studio.

In aural broadcasting there is increased interest in stereophonic reproduction. RCA and NBC have field tested a simplified AM stereophonic broadcasting technique requiring only minor modification of the AM transmitter to produce the desired angular modulation of the output. The transmitted signal furnishes complete information to the conventional receiver and the stereophonic receiver has simple circuitry. Westinghouse has field tested their AM/FM duplex stereophonic system over station KDKA. The Federal Communications Commission (FCC) is giving consideration to adopting stereophonic standards for both AM and FM broadcasting. At the present time, most of this broadcasting takes place by using a separate AM and FM channel. Also, stereo reproduction is available on tapes beside the wide scale use of records using 45/45-degree type of stylus operation. There has been a steady growth in color television programming and a growing ownership of receivers capable of receiving both color and monochrome transmissions.



Low-cost data-transmitting terminal includes keyboard and card-reader device plus modulator, and requires no local power.

The advent of a commercially available television receiver employing transistors throughout as evidenced by the Philco "Safari" is a significant step in the transistor art. General Electric has been active in the development of high-frequency transistors, such as tunnel diodes, which have possible future application in vhf and uhf television.

COMMUNICATION THEORY

THE TREND TO INCREASED USE of statistical methods in analysis of continuous signals is evident in papers reporting further results on the properties of noise and on such questions as optimum filtering and the estimation of filter parameters from response to noise. New papers on experimental errors, the uncertainty principle, and their relation to information theory have appeared. In the area of information processing theory, new results include several studies of error correction and error detection in unreliable automata, automatic recovery, and of restoring organs in redundant automata. Simulation of learning, and the study of both computer languages and natural languages as well as pattern recognition have continued.

Channel capacity for a number of complex channels, including channels with memory, with side information, with feedback, and 2-way channels have been studied. Coding theorems for a discrete channel with a fidelity criterion have been reported in one paper. Studies of quantized television coding and of computer simulation of picture coding have been published. A machine for automatic recognition of hand-sent Morse Code has been built. Important new results in code construction indicate a trend toward the use of more powerful mathematical principles. An exciting development is the use of binary error-correcting codes as the basis for load-sharing switching matrices for applications such as computer memory addressing. These load-sharing matrices are not only considerably more economical than conventional matrices, but also are capable of automatic error correction.

DATA COMMUNICATION

THE YEAR 1959 has seen significant progress and development in arrangements to provide electrical communication of data. It has been a year of extensive compatibility testing of business machine terminal devices with data-transmission facilities. A number of companies are working on terminal devices and arrangements for transmission of paper tape, magnetic tape, and punched cards over voice grade facilities at a variety of speeds from about 75 to about 2,000 (in some instances, 5,000) bits per second. The Collins Kinetape equipment and the telephone companies' "Data-Phone" service are examples. Also, various military applications for data transmission were announced—some operating at very high bit speeds.

At the lower end of the speed scale, there was demonstrated a complete data-transmitting terminal including a low-cost keyboard and card reading device plus a modulator, which requires no local power. It uses a spring-driven reader and a multifrequency transistor modulator which is powered by the telephone "talk" battery.

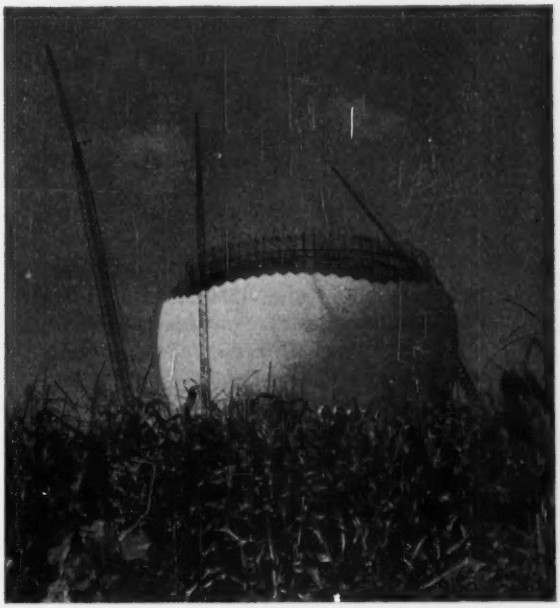
Several countrywide airline reservation systems were

announced, each involving extensive data communications to connect outlying points to a centralized computer. Also, the airlines began to print tickets remotely at customer locations using teletypewriters.

RADIO COMMUNICATION SYSTEMS

INDUSTRIES AND GOVERNMENT AGENCIES have been actively participating in the development of satellite radio communication systems for point-to-point communications. This brings in the possibility of relaying worldwide television programs and divorcing the dependence of communications circuits from ionospheric vagaries, thereby increasing reliability.

The application of single-side-band techniques to point-to-point long distance radiotelegraph circuits promises the greatest growth possibilities in this field since its inception. Single-side-band and independent-side-band radiotelegraph systems allow for a high degree of frequency-division multiplexing as contrasted to the requirement for time-division multiplexing in the usual frequency-shift-keyed carrier systems.



This strange-looking structure under construction is a prototype of similar installations to be constructed in the Far North. It will be used by RCA to test equipment for the Air Force's Ballistic Missile Early Warning System. Giant dome is 140 feet in diameter atop a 3-story building; and, when installed in the North, it will provide storm protection for the huge radar antennas inside designed to track enemy missiles. Dome, fabricated by Goodyear Aircraft Corp. is made of paper pressed into honeycomb design and faced with plastic-impregnated fiberglass.

The past year has seen further increases to all parts of the world in customer-to-customer teleprinter service via radio multiplex circuits equipped with automatic error-correcting equipment. Transistorization of multiplex and automatic error-correcting equipment has been accomplished and installation of switching facilities to provide immediate connection of customers on international radio circuits is underway.

Studies and advances have been made to utilize radio communication systems for record data processing including computer-to-computer communications.

For the first time in history, the moon has been tracked continuously by radio through the use of a new precision radio sextant.

A prototype of the complete communication system for Project Mercury, the National Aeronautics and Space Administration's manned-satellite program, was completed to provide voice communications for the pilot and telemetry during the orbital phase of the mission.

A powerful tracking radar has been developed as a key unit in the U.S. Air Force's Ballistic Missile Early Warning System (BMEWS). The over-all system is designed to detect enemy ballistic missiles shortly after launching and provide warning to the Strategic Air Command and other defense agencies.

Proceedings now under way before the FCC are again exploring the possibility that a large block of frequencies might be made available for extension of telephone service to moving vehicles on a large scale which can develop into universal mobile communications via radio for the first time.

Electronic control devices developed for the "highway of the future" are being tested for use in controlling jet-age traffic at airports.

TELEGRAPH SYSTEMS

MANY NEW DEVELOPMENTS in the field of telegraphy were brought forth during 1959. The trend toward the transmission of larger proportions of numeric material, coupled with the transmission of material to and from computers over the communication networks, has generated demands for telegraph systems of higher speeds and greater reliability.

One of the recent developments in high-speed telegraphy is the *TT195()/FG* reperforator teletypewriter developed for the U.S. Signal Corps. This unit produces a punched paper tape with printing at line speeds of 60 to 750 words per minute. The reperforator utilizes solid-state devices liberally, restricting the role of mechanical devices to the final tape perforating and printing functions. The complete set weighs only 55 pounds, occupies 1.5 cubic feet of space, and requires only 175 watts of a-c power.

Considerable activity has taken place, during the past year, in the review of the error rates of standard telegraph systems and the development of means to detect (and in some cases correct) errors. New developments in error detection have been based on the generation of check characters at the end of a block of characters (usually a line of copy for a page printer).

A new fully automatic teletypewriter switching system capable of line speeds up to 100 words per minute (wpm) and cross office speeds of 200 wpm has been

The 828 fully automatic teletypewriter switching system was placed in service for the U. S. Navy as a part of their worldwide communication network.

placed in service for the U.S. Navy. The switching system avoids the use of common units of equipment, the failure of which might disrupt an entire switching center. Two types of completely self-contained packaged units are used to build-up an entire switching center which, by means of plug connections, permits simplified and rapid installation.

Vestigial side-band techniques as well as progress in delay distortion measurement and correction have assisted the growth of facsimile by increasing the speed of satisfactory operation. The U.S. Air Force was provided with an improved nationwide facsimile network for high-altitude weather information. The network links 57 Strategic Air Force bases throughout the country and operates at double the previous speed. A new transcontinental public facsimile service was inaugurated with service initially being offered between New York, Washington, Chicago, Los Angeles, and San Francisco. The network provides for the transmission between these cities of full-page communications, letter-size documents, drawings, and other recorded data.

General Applications Division

AERO-SPACE TRANSPORTATION

SIGNIFICANT DEVELOPMENTS were made during the past year in the field of unconventional power sources for applications in space. High on the list are the developments in the field of thermoelectrics. An example is the SNAP III isotope fueled generator which was designed to demonstrate the feasibility of thermoelectric power supplies for space vehicles. Also worthy of mention are advances in solar cells, solar collectors, thermionic generators, nuclear heat sources, and electrostatic generators. Some of these developments were reported at the AIEE Summer and Pacific General Meeting and Air Transportation Conference in Seattle, Wash., in papers sponsored by the Aero-Space Transportation Committee.

Aircraft-type constant-frequency generating systems which do not require the use of constant speed transmissions also were reported at the Seattle meeting. In the new variable-speed constant-frequency (VSCF) systems, the rotating machine is operated at variable engine speed and the constant frequency output is produced by electrical means. Some systems use the synchronous flux principle wherein the generator is of the induction type with pulse phase rotor windings. This rotor winding is excited from the output of a frequency changer made of semiconductor devices which generates slip frequency of the proper phase sequence by accepting variable frequency power from an exciter mounted on the same shaft. In other machines, power generated at a high frequency (several times the required output frequency) is connected to the output terminals through a static switching system which reverses the polarity of connection at the high-frequency rate. The output polarity and amplitude are directly dependent on the field polarity and amplitude. Hence an alternating current of accurate frequency applied to the field produces an output of the same accurate frequency independent of speed. Outputs up to 100 kva are possible with existing semiconductors.

Large quantity usage of airborne solid-state devices became evident during 1959. Experimental versions were supplanted by their production equivalents.

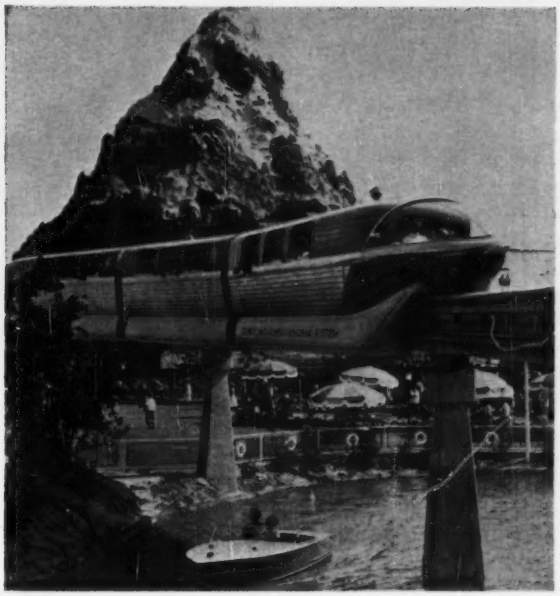
The commercial jet age of 1959 brought with it the everyday usage of both constant- and variable-frequency airborne electric power systems. The transition from military to commercial transport usage of these systems attests the attainment of adequate reliability for adoption by airlines.

DOMESTIC AND COMMERCIAL APPLICATIONS

MAJOR PROGRESS IN THE FIELD of domestic appliances during 1959 was not of the spectacular variety involving new discoveries and completely new products. It involved, rather, a healthy trend toward more thorough engineering analysis of products and a greater amount of basic research and fundamental development.

The consumer product field is evolving from its initial base of brilliant mechanical tinkering to a level where large numbers of scientists and engineers are using sound analytical approaches to the problems of the family living needs of man. There are definite indications that the domination in this field by sales groups is being tempered by recognition of the necessity for good sound engineering practices. The recession of 1958, which had some basis in consumer rebellion against gadgetry and mere face-lifting at the expense of quality, service, and true function, gave the appliance engineer his opportunity to be a greater influence toward true long-range product planning. In this respect, it is felt that 1959 marked a turning point, and its effects will be reflected over the years ahead.

In major appliances, laundry equipment control has been adapted to the many conditions imposed by new fabrics, providing greater flexibility in use.



View of Disneyland's monorail system.

The year 1959 continued to point up the fact that there is no apparent limit to the domestic tasks that can be done better electrically. The electric can opener, although not a new product this year, came into its own as a large volume item, with many new companies entering the field. Another single purpose item, a hot dog cooker, received outstanding acceptance.

In the field of home heating, the year was marked by a rapid expansion in the number of electrically heated homes. Noteworthy is the effort being made by various agencies to obtain realistic means for estimating costs of electric heating.

LAND TRANSPORTATION

THE W. E. DISNEY ENTERPRISES are operating in Disneyland the first electrically propelled monorail system. This system was put into operation during the early summer of 1959. It is the first full-size monorail system designed along the lines of the ALWEG type.

The inauguration of this system was shown on a national television hook-up in connection with the Disney Hour. Vice-President Richard Nixon and family participated prominently in this affair.

The system consists of a loop monorail approximately three-quarters of a mile long. Two trains consisting of three cars each are being operated on this loop. Each train is propelled by two 300-volt motors. The train weight including passengers is 40,000 pounds; top designed speed is 24 mph.

The system includes the first silicon rectifier for railway power supply, rated 600 kw, 300 volts.

A large number of applications of electricity in operations and control of railroads are now in use. Some of these are: car accelerators, retarders, speed controls, and automation of freight classification yards; also traffic controls and information centers on large systems such as New York Central, Seaboard Air Line Railroad Company, and others.

MARINE TRANSPORTATION

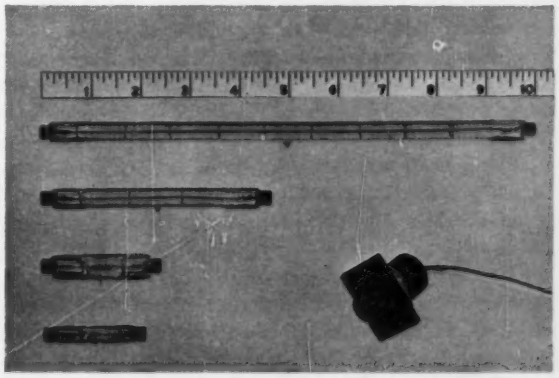
THE USE OF ELECTRIC POWER for all purposes aboard ship has continued to grow so that the ship's service system capacity on the largest vessels now being built totals 20,000 kw. Since this power, generated by multiple sets, is produced and utilized at 450 volts a-c, high current-interrupting capacity is needed in the associated switchgear. The use of circuit breakers combined with high interrupting-capacity fuses has been found advantageous on these systems and this practice is now being followed extensively on new construction. This combination of high interrupting-capacity fuses and relatively low-capacity circuit breakers avoids the use of large back-up breakers and permits more direct distribution of power from high-capacity systems.

A novel arrangement of a small propulsion system in a crosswise position at the bow of a large vessel improves the maneuvering ability to a marked degree. The sidewise thrust produced can be used to counteract the effect of adverse winds and currents and facilitates docking and controlled movement of the vessel under difficult conditions. A bow thruster of this type is being installed on a new high-powered dredge now being built for the U.S. Corps of Engineers. The main propulsion and dredging equipment on this vessel is of the usual type, but the characteristics of the vessel are expected to be improved materially by the inclusion of this bow thruster.

PRODUCTION AND APPLICATION OF LIGHT

THE YEAR 1959 brought forth several significant and fundamental developments in light sources and associated equipment and an increased acceptance by users of the need for and benefits to be derived from higher lighting levels.

Several significant developments have been introduced by manufacturers of fluorescent lamps. A new



New all-quartz tubular lighting lamps which retain 99% of original output throughout life and permit precise optical control of light.

noncircular cross-section 1,500-milliampere lamp provides a 15% increase in light output. Fluorescent lamps designed for the outdoor market have been introduced, including a jacketed design for exposed applications. The popular 40-watt rapid start lamp has become the universal lamp for both 40-watt preheat and rapid start circuits. In new designs of standard lamps, efficiencies have been significantly increased and now approach 80 lumens per watt. The concept of panel or area fluorescent lamps was introduced for future application. U-shaped and fluorescent lamps with internal filament ballasts have also been announced.

Unique in the incandescent lamp field was the development of thin tubular quartz lamps for general lighting. As a result of a regenerative iodine cycle, the lamps do not darken during life. The size of the source makes possible extremely well-controlled light distribution from fixtures.

In the field of measurements, the National Bureau of Standards has installed a new primary standard. An ingot of pure platinum is heated electrically by a 450-kc generator.

The development of high-current silicon-controlled rectifiers has resulted in improved compact theatrical lighting dimmers. For laboratories, hospitals, and other areas where equipment sensitive to fluorescent lamp radio interference is used, a glass lighting panel has been developed which eliminates such radiated interference from the fixture.

To further improve the efficiency of fluorescent street-lighting luminaires, a design utilizing a Peltier thermoelectric heat pump to maintain lamps at near optimum efficiency over a wide range of ambient temperatures has been developed.

New developments in transportation lighting featured high-frequency operation of fluorescent lamps at 3,000 cycles and higher on busses.

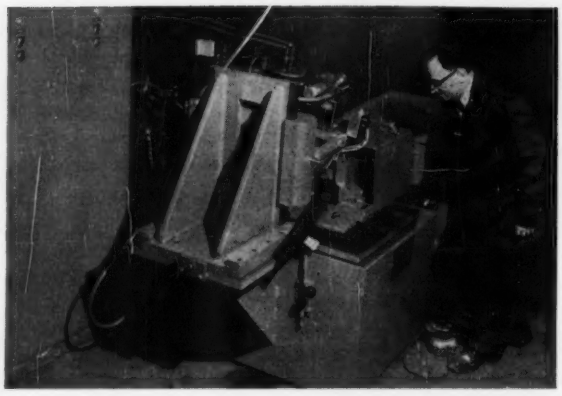
Electroluminescent panels of low brightness are finding application in residential night lights, highway signs, and aircraft and automotive instrument panels.

Industry Division

ELECTRIC HEATING

In 1959, electric heat made it possible to reduce the size of equipment necessary for certain operations. Two separate examples are a portable asphaltic concrete hot mix plant, and a tube mill which takes only a fraction of the space required by conventional mills.

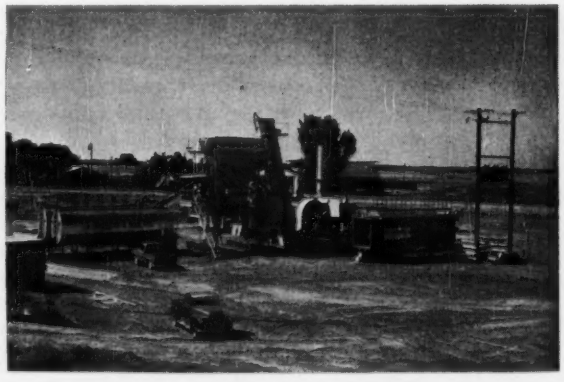
The asphalt plant, developed by A. Teichert & Son, is self-contained, including switchgear van. It uses 500 kva, including 172 kw for heating. Two 12,000-gallon insulated trailer-mounted asphalt tanks are kept at 350 F by 36-kw immersion heaters. A 12,000-gallon Bunker *C* fuel tank is kept at 130 F by a 20-kw heater, and a 60-kw booster raises the fuel to 350 F before burning. Another 20-kw immersion unit heats closed-system piped oil, pug mill, asphalt pump, and hopper. Time-clock control turns on the heat before the shift starts.



Thermatool spiral-forming tube mill and thermatool high-frequency welder making 2-inch OD tube.

The plant mixes an 18-ton dump truck load in less than 5 minutes. Electric heat makes this automatic batch operation possible close to the paving job, providing a steady stream of hot mix to exacting specifications, using fewer trucks with less loss of heat in transit, resulting in higher quality lay. Operating costs are reduced over conventional systems because of the clean and maintenance-free operation.

Another example of ingeniously applied electric heat is a high-frequency resistance-welded spiral tube mill developed by the New Rochelle Tool Corp. It winds strips of almost any metal into long straight sections of tubing, and continuously welds the spiral seam. High-frequency current, introduced through sliding contacts, heats the two edges at high speed and brings them to welding temperature where they come together. The supply consists of vacuum-tube power oscillators of output ratings of 25 or 60 kw. This equipment is much smaller than conventional mills for the same size and thickness of tube and permits easy changeover for different sizes. Very large diameters can be made with simple equipment. Production rate is high. The mills are easily moved from one place to another and even



All-electrically heated asphalt tanks are shown at left and Bunker C tank is at right behind power van.

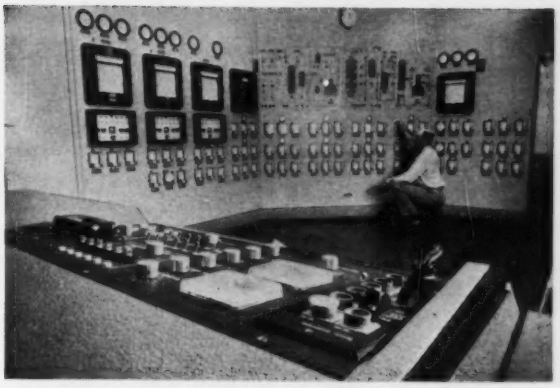
could be set up in the field for pipeline laying applications.

FEEDBACK CONTROL SYSTEMS

INTERNATIONAL INTERCHANGE of information in the field of automatic control has moved a step forward to reality in 1959 with the acceptance of a number of technical papers for inclusion in the First International Congress of the International Federation of Automatic Control (IFAC) to be held in Moscow, USSR, June 1960. The American representation on IFAC is the American Automatic Control Council (AACC) comprised of representatives of the major professional societies. The IFAC was founded in 1957 with Harold Chestnut, then chairman of the AIEE Feedback Control Systems Committee, as its first president.

It is particularly noteworthy that the first attempts to establish standards on components of feedback control systems was instituted in 1959 through a subcommittee on control components. Some of the first attempts have been made on transformers and on electrohydraulic servo-valves.

The biggest equipment news in control systems continues to deal with matters of space technology, computers and control, and nuclear equipment. It is recognized that one of the major factors in the Soviet achievement of launching a rocket to the moon involved the development of a superb control system. Reports on this system indicate outstanding achievements in gyroscopic computer control and beam-riding techniques.



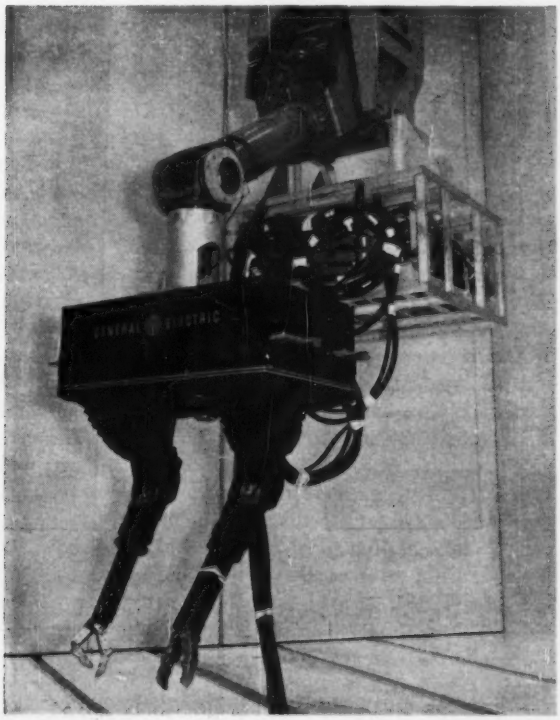
A Thompson Ramo Wooldridge RW-300 digital control computer (foreground) controls an 1,800 barrel-per-day catalytic polymerization unit at Texaco's Port Arthur (Texas) refinery. This is one of the first commercial industrial processing units to be put under closed-loop computer control.

Commercial chemical computer control became a reality in 1959 as the *RW-300* digital computer of Thompson Ramo Wooldridge Inc. was installed and operated on-line at the Texaco Port Arthur Works. The digital computer diligently controls a 1,800-barrel-per-day catalytic polymerization unit maintaining reactor bit temperatures between 470 and 490 F, at 700 to 740 psi (pounds per square inch)—a difficult feat in view of several fluctuations in gas feedstreams. While taking measurements and readings from 110 sources and controlling 16 different streams, pressures, and temperatures in nearly every combination, the *RW-300* checks its own accuracy, types out what it is doing and sounds an alarm when required.

Digital control of machine tools has gained tremendous impetus. As an example, the General Electric Company working with the Ex-Cell-O Corporation has produced a numerical tape-controlled contour milling machine. This new machine working with an IBM *704* computer to produce the data for the director is effective in substantially reducing manufacturing time. In steam bucket fabrication, parts are sufficiently accurate that this machining system will be used to produce bucket masters for the cam-follower-type machines.

Leeds and Northrup have installed six or more analog computers in computer-control of electric power systems. The computers utilize feedback from the power system to maintain "Area Requirement" (the basic operating parameter) at, or near, zero. They also employ intermediate feedback from generating station outputs and combine these data with feed-forward to predetermine the ultimate destination point for each generating source before any change is made.

A significant refinement in the field of remote manipulators for use in nuclear radiation environment has been announced by the General Electric Co. Handyman, remote manipulator with feel, permits a closer



Handyman slave station shown being moved about in the hot shop of the General Electric Aircraft Nuclear Propulsion Department at the Idaho Test Station.

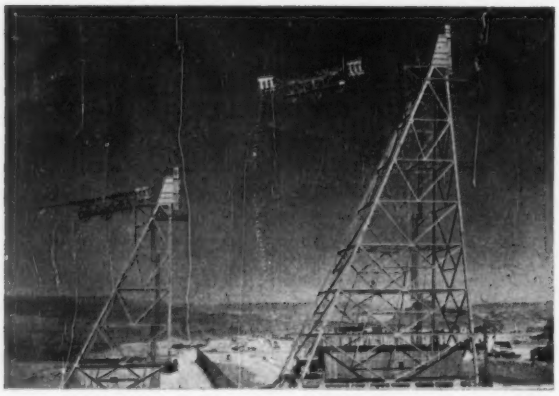
coupling between the touch senses of the operator and the manipulator in its nuclear radiation environment. This manipulator which enables the operator to experience the same feel sensations as the remote manipulator, is composed of five basic units—master, slave, electronic console, and two hydraulic pumps to power the master and slave. The slave and master have two arms and hands. Ten basic motions are designed into each arm and hand—finger bend, finger curl, thumb bend, thumb curl, wrist bend, forearm twist, elbow bend, upper arm twist, forward and sideward shoulder pivots. Applications of this kind along with the existence of computer control have further moved comprehensive feedback control systems far beyond the range of experimental uses into the industry where they are earning their way.

GENERAL INDUSTRY APPLICATIONS

SOME OF THE SIGNIFICANT ACCOMPLISHMENTS during 1959 were:

1. Fiber Spinning Machine Drive. Fiber spinning machine drives are of such a nature as to require a high degree of system accuracy.

A "Rectiflow" adjustable-speed drive (modified Kramer drive) has been designed with a proportional plus integrator-type transistorized regulator governing the excitation through controlled silicon rectifier. The integrator function provides extremely good accuracy by integrating out any frequency (or speed) deviation thereby reducing the steady-state error signal to essentially zero. The proportional function supplies the gain necessitated by transient disturbances upon the system.



View of new high-speed concrete pouring cableways, four of which were built for use in the construction of Glen Canyon and Flaming Gorge Dams in the Upper Colorado River Basin. The two cableways at Glen Canyon Dam site are rated 50 tons with 12-cubic-yard buckets and a maximum hoist speed of 700 fpm (feet per minute). The two cableways at the Flaming Gorge Dam site are rated 25 tons with 8-cubic-yard buckets and a maximum hoist speed of 350 fpm.

The outstanding feature of the integrator type system is the ability to give high accuracy without the requirement of extremely high gain.

2. Senate Subway Cars. The U. S. Senate's subway system consists of four cars, each seating 18 passengers and an operator. The cars run between the Capitol and the Senate office buildings.

Control of each car is similar to that of an elevator, utilizing d-c shunt motors and a variable-voltage system. The a-c–to–d-c motor generator set on each car is supplied from a 230-volt, 3-phase, 60-cycle unit substation through a 3-wire overhead trolley system. The control sequence is fully automatic and is initiated from the operator's master switch. Top speed of each car is 20 mph.

3. Tire Test Machine. A regulated adjustable-voltage drive of the double armature type rated 2,600-hp continuous, 7,800-hp peak, has been installed on an aircraft tire test machine at a large rubber company plant. An important feature of the regulating system is a transistorized integrating amplifier that removes speed error of more than momentary duration and permits the drive to follow programmed ramp function speed changes with high accuracy. The regulator is designed to accept a speed reference signal available as a voltage from a curve follower; thus, the speed pattern is programmed from curves drawn on paper.

The remaining amplifier stages in the regulator are magnetic amplifiers designed for fast response to utilize the peak torque capacity of the drive to limit speed deviation on impact loading. Current limit is incorporated to protect the rotating machines.

INDUSTRIAL AND COMMERCIAL POWER SYSTEMS

NEW UNDERSTANDING was revealed in 1959 of the role played by conduit in determining the amount of ground fault current on grounded neutral systems. Calculation of the current-limiting effect of inductance introduced by steel conduit compared with the lack of such current-limiting inductance with aluminum conduit gave rise to new criteria for design of long grounded neutral circuits to avoid choking fault current below instantaneous trip levels. Long steel conduit runs can reduce fault current sufficiently below instantaneous trip levels to permit damage during the interval before overload interruption takes place.

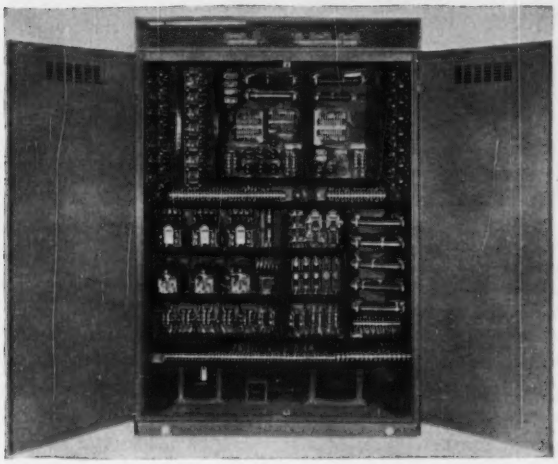
A novel 4-part system for electrical record drawings was disclosed in 1959. The system utilizes four types of drawings: plot plan, block diagram, 1-line diagram, and elementary diagram. This combination of diagrams provides complete information required to maintain and expand industrial plant distribution systems. Advantages of the system are that future changes can be accommodated easily and physical locations are shown.

Recognition of load interrupters and power fuses by the June 1959 revision of the National Electric Code focused new attention on these devices for power systems in industrial and commercial buildings. Properly metal clad in unitized enclosures, these devices offer an economically optimum solution to switching and protecting high-voltage power supply circuits wherein the performing equipment closely matches the actual needs of the system.

COMPLETELY STATIC POWER SUPPLIES have been developed for adjustable-voltage drives for two important textile industry applications.

Four power and control units in ratings from 20 hp to 100 hp provide power for adjustable-speed operation of sections of a cloth finishing range, each having from 3 to 10 d-c motors. The voltage to the motors is controlled by power magnetic amplifiers incorporating silicon rectifiers. The control of speed or matching of voltage between sections is provided by a magnetic amplifier having a rate control circuit to provide static means for controlling acceleration and deceleration.

A static power supply for multimotor slasher drives incorporates power magnetic amplifiers with silicon rectifiers for supplying armature power to all motors and booster power for the beam winder motor. In addition to the magnetic amplifier for control of speed and acceleration and deceleration rates, a magnetic amplifier regulates armature current to the beam motor by controlling its field, and thereby provides control of yarn tension.

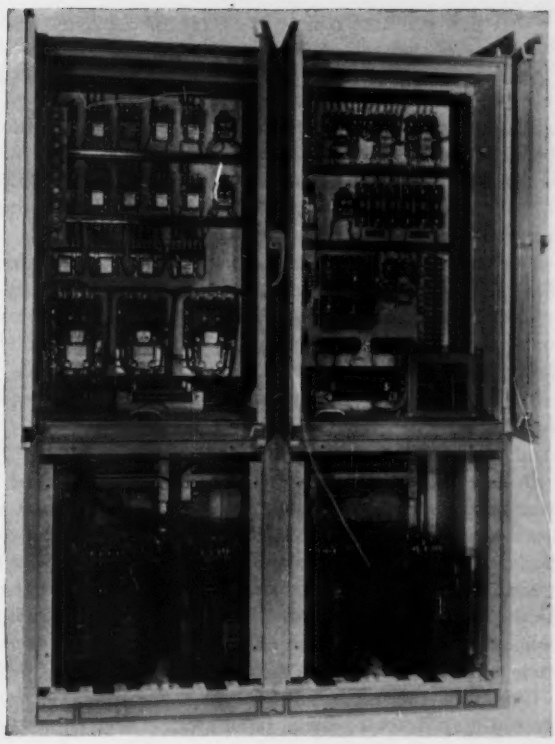


Static slasher drive for textile mill.

Static control is employed to erect the Atlas missile from a horizontal position to firing position. The controls meet stringent military specifications and employ static control components for utmost reliability and minimum maintenance.

The React-O-Verse primary saturable reactor control operates the 75-hp a-c drive motor, utilizing a tachometer feedback-type Magamp speed regulator. It is designed so that the drive cannot regenerate and, therefore, it always presents a positive load to the a-c power supply. Slow down and driving torque is controlled to obtain smooth operation.

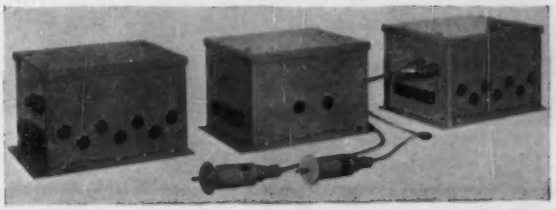
The Cypak sequence control receives intelligence from limit switches, and upon operation of a single start push button, the erection cycle is started, provided certain preliminary functions have been completed. At 90 degree boom position, the drive comes to a controlled stop, the missile is automatically transferred to the launcher, and the boom moves on to the 110 degree position. The lowering cycle is controlled in a similar manner. Erection and lowering is monitored to give visual indication of the erection and lowering cycle at all times.



Control for Atlas missile erector.

A newly developed tensiometer is operating successfully on a Sendzimir mill at the Stainless Steel Division of Jones & Laughlin. The strip tension is measured by a deflector roll with very small displacement.

Precision differential transformers are used as electromechanical transducers. The small signals are amplified in two separate all-transistorized metering and regulating amplifiers. Strip tension is indicated on an instrument and recorded on a chart recorder. A strip break



A newly developed tensiometer used successfully by the Jones & Laughlin Steel Corp.

detector is included which will shut down the mill in the event of a fault.

METAL INDUSTRY

THERE HAS BEEN an almost universal acceptance of punched card programming of reversing hot mills. The degree of programming on mills now in operation varies from setting of roll openings and mill top speed to completely automatic operation of all significant functions on several mills.

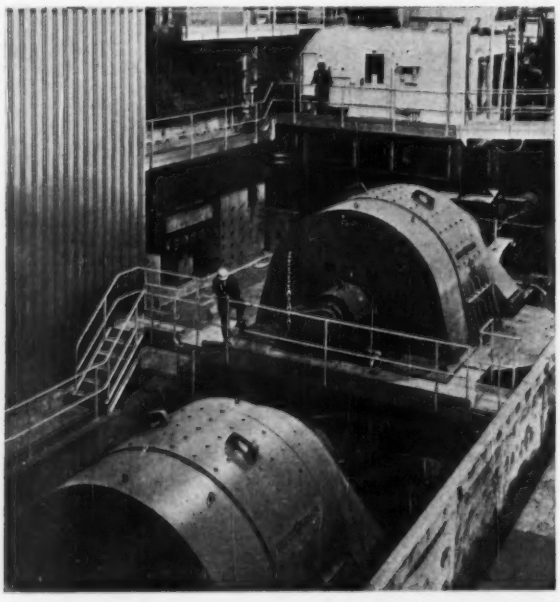
During the year, a considerable number of automatic digital data-processing systems were installed and placed in operation in steel plants. Typical of the intermediate form is the electrolytic tinning line data-acquisition and data-classifying system. The purchase by the can manufacturers of tinplate in large coils rather than in graded sheets has necessitated a permanent, accurate, easily available record of the defects within each coil shipped.

During the running of a coil, signals are obtained from defect sensors and a footage or pulse tachometer. Logic circuitry is used to classify the tinplate into trade grades of "Prime," "Mender," and "Waste-Waste" as determined by the defects and combinations thereof. At the completion of a coil, typewritten and punched tape records of the number of feet of each defect and trade grade are automatically prepared.

Currently, interest is centered on the more sophisticated digital process control computers. The computer operates in accordance with an internally stored program to translate process data continuously and automatically into information useful in making decisions with relation to the over-all process. When indicated necessary by its program, it also involves making the required decisions to cause reprogramming of process set points. Process computers promise a significant advance toward achieving process optimization.

Processes receiving active attention include blast furnace, sintering plant, reversing hot mill, hot strip finishing mill, continuous annealing line, electrolytic tinning line, and plant utilities.

Operation of the computer is in four functional categories: (1) control, (2) data acquisition, (3) production accounting, and (4) monitoring and protection.

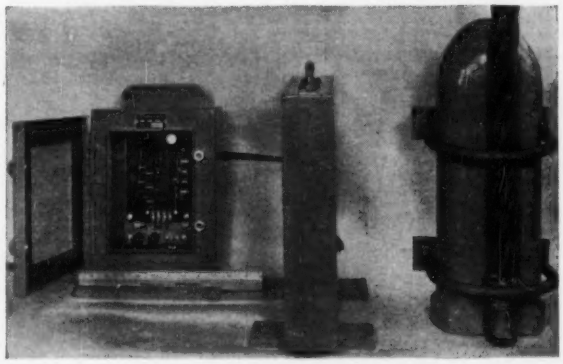


Courtesy General Electric Co.

Lukens Steel's new 140-inch plate mill is driven by two 5,000-hp, 40/80-rpm motors employing the new "top-forward" arrangement. D-C power is supplied by an 8,000-kw back-to-back ignitron rectifier equipment, one of the first installations on a large reversing mill.

MINING INDUSTRY

THE PAST YEAR was one of progress for the mining industry in the field of electrical engineering. Important contributions in the form of new products to enhance the safety and efficiency of mining operations were completed and satisfying progress was made on other developments which have not yet made their appearance on the market.



Courtesy Canadian Westinghouse Company Ltd.

View of fully transistorized, fail-safe mine hoist alarm and cage telephone. Device provides a rugged and reliable mine-shaft communication system.

As in past years, a fine spirit of co-operation between the U. S. Bureau of Mines, the manufacturers of mining machinery and electrical equipment, and the various interested engineering and trade groups has been largely responsible for the developments in the area of safety.

Important progress has been made on the development of a methane detection device which would remove the power from a mine section whenever the concentration of explosive gas reaches a dangerous percentage. This device will be ready soon for field tests.

Long recognized as one of the serious dangers of mining, explosions and fires originating from trailing cable failures are minimized by an electronic device, approved by the Bureau of Mines, which will remove the power from the machine and cable in case of ground faults. Previous devices protected only the machine.

Photography at the working face of a coal mine is facilitated with safety by development of a Bureau of

Mines approved flash device for both the miniature and large lamps.

A fully transistorized, fail-safe, mine hoist alarm and cage telephone has been developed to meet the need for a rugged and reliable mine shaft communication system. It is particularly useful during periods of shaft inspection.

In the area of open pit machinery, 1959 witnessed greater activity in the specification of the giant (above 50 cubic yards) electric shovels, and the beginning of commercial manufacture of the electrically powered wheel excavators for moving heavy tonnages of overburden.

PETROLEUM INDUSTRY

IN OIL PRODUCTION, refining, transportation, and marketing, electrical technology is extending the capability and efficiency of the industry's operations.

Consider the basic electrical tool—the motor. Until recently, for many applications, the vulnerability of motor insulation to unfavorable environmental conditions such as moisture and airborne reagents required costly total enclosure. Today's advanced insulation systems make it practical in many such cases to employ motors of standard weather-protected or even drip-proof construction at substantial saving in cost. The new insulation techniques provide more durable motors for oil well pumping, make feasible in many locations the installation of pipeline pump units outdoors with resultant simplification and economy of station design, and provide important savings in refinery drives in Division 2 areas through the use of weather-protected or drip-proof motors rather than the more costly totally enclosed fan-cooled type.

Another direction in which oil industry electrification is making remarkable progress is that of automatic and remote control. Increased reliability of motors and motor control, including protection and automatic sequence systems, has contributed greatly to this development. In the present decade, over 200 pipeline pumping stations and valve locations have been put under operation by remote control, using communication channels over landlines, powerline carrier, or microwave radio. The industry makes wide use of digital techniques for the transmission of operational information, and the logging of process data by electric typewriter has become commonplace where information must be maintained on large numbers of operating variables.

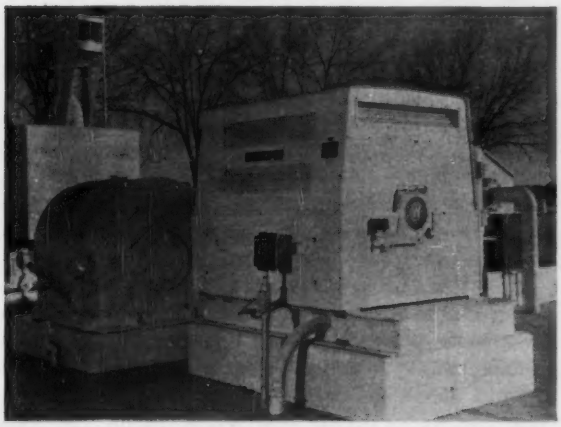
Keeping pace with the developments in supervisory control and data transmission is a rapid increase in the use of computer technology not only for analytical services but also for process control.

Instrumentation Division

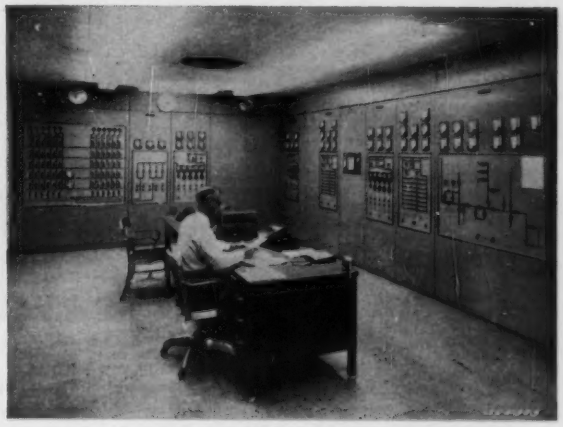
INDICATING AND INTEGRATING INSTRUMENTS

IMPORTANT ADVANCES in the field of power measurement were made with the Westinghouse Hall-effect watt transducer and the Weston Inductornic wattmeter. The Hall-effect has been economically applied as a solid-state, quick-response accurate transducer resulting in further progress toward reduction in the variety of mechanisms required for electrical measurements. The Inductronic wattmeter makes precision watt measurements possible by a null method.

In the field of integrating meters, formal recognition of the extended ranges over which watt-hour meters of all manufacturers can operate within the limits of commercial accuracy has been made through adoption by the industry of a new "class" terminology. The "class" denotes the maximum of the load range in amperes. Two standard classes for self-contained meters have been recognized, Class *100* and Class *200*, which conform with the trend to 100-ampere and 200-ampere services. Transformer rated meters are required for loads of over 200 amperes and a third class, Class *10*, has been standardized for these meters. The "class" nomenclature is now shown on meter nameplates and is included in manufacturers' catalogs.



Modern motor insulation makes the outdoor pumping station practical. View of a 400-hp weather-protected motor in pipeline service.



Control room of a 600-mile crude oil line. Pumping and pressure control stations are remotely operated by supervisory radio control.

NUCLEONICS AND RADIATION INSTRUMENTATION

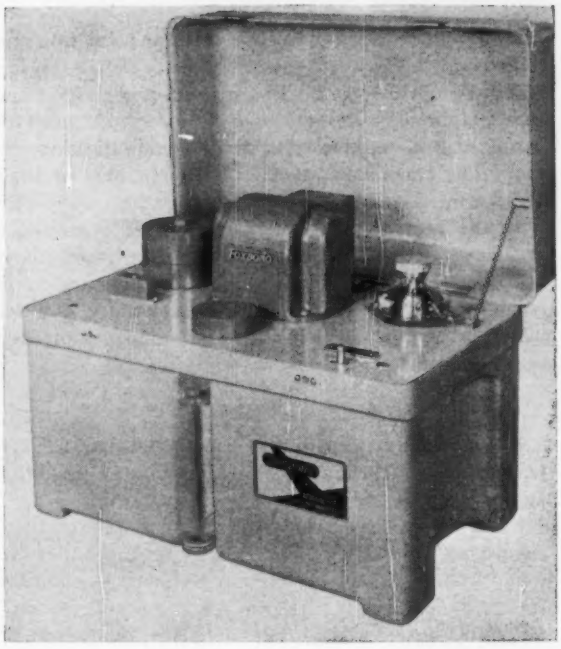
DURING THE EARLY STAGES of development of the nuclear industry, the major efforts and development were quite naturally found in the Atomic Energy Commission (AEC) Laboratories. In recent years, some work has been done in repackaging the AEC developed instrumentation, but the industrial approach has been chiefly toward new designs. Substantial impetus has been given this effort by the nuclear submarine program. Many of the requirements placed on maritime reactor instrumentation are directly applicable to power reactors, and the instrument companies, therefore, have a strong incentive for participating in the development work. In the maritime and power reactor fields, solid-state devices have to a large extent replaced electron tube instruments. It is now possible to order solid-state reactor instrumentation systems from several companies. Component solid-state instruments are available from an even larger number of companies.

The relatively high cost of solid-state instruments along with lack of proof of projected reliability has so far discouraged their use in research reactors. The same reasons have limited the use of solid-state devices in nuclear laboratory and research equipment. A start has been made however, and the way seems clear for future progress along these lines.

Progress in nuclear detectors appears to be limited largely to increasing operating temperature limits. One other noteworthy development was the perfection of a miniature semiconductor neutron detector.

RECORDING AND CONTROLLING INSTRUMENTATION

PROGRESS IN THE DEVELOPMENT and application of industrial instrumentation continued to accelerate during 1959. While major attention was given to digital computer control systems, many advances were made in sensing elements, transducers, high-impedance electronic amplifiers, and analog measuring systems. The trend toward the increased use of solid-state components in electronic instrumentation continued.



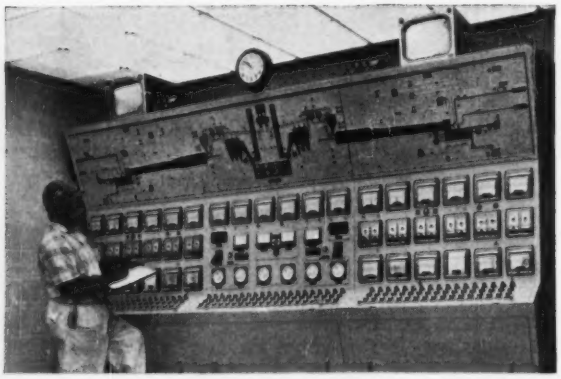
Courtesy Foxboro Co.

Residual chlorine table-mount analyzer unit—exterior view, top open.

General purpose digital computers were used not only for recording measured and computed quantities, but also for control of complex processes from refineries to electric power generating systems. This emergence of computing control has resulted in the establishment of engineering teams to bridge the application gap between availability of hardware and installation of practical systems. Instrument makers have developed electronic measuring devices capable of feeding computers, and also capable of receiving computer signals which, based on programmed factors, can automatically adjust controller set points to optimum values.

Much attention was given to "on stream" analytical devices. These are valuable to industry as they measure product qualities directly rather than inferentially. Amperometric measurement has been furthered through the development of reliable and continuous sampling techniques which permit municipal water supplies to determine the effectiveness of chlorination procedure. Gas chromatography has been used in an increasing number of industrial applications. Interesting developments in this field include shorter analysis time, with consequent improvement in process control.

A number of new or improved measuring systems and components were made available. These include bolometer-type radiation sensing elements; high-impedance amplifier for self-balancing instruments, which permits measurement of pH directly from glass electrode; solid-state digital information systems; electronic control devices; and a multiple-point recorder with



Courtesy Foxboro Co.

Electronic "consotrol" semigraphic console cabinet containing electronic consotrol indicators, recorders, and controllers. Located in main control room for control of cement kilns at Riverside Cement Co., Oro Grande, Calif.

push-button means for selecting or changing the number of points to be recorded.

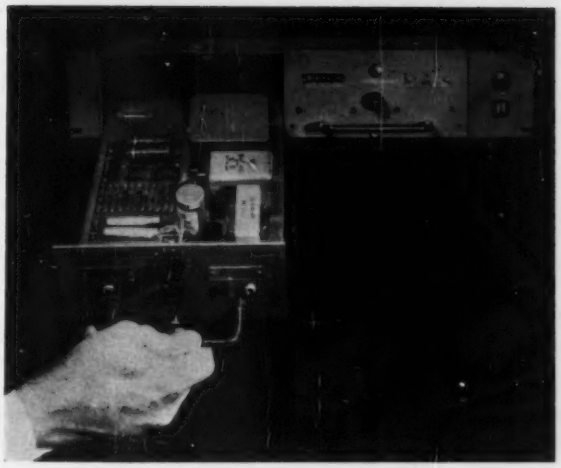
TELEMETERING

MARKED ADVANCEMENTS in mobile and point-to-point or stationary telemetering were recorded in 1959 in both design and application. One has but to read the daily newspapers with their spectacular reports on rocketry and satellite launchings to become aware of the large amounts of mobile telemetering being used for successful operation and report-back.

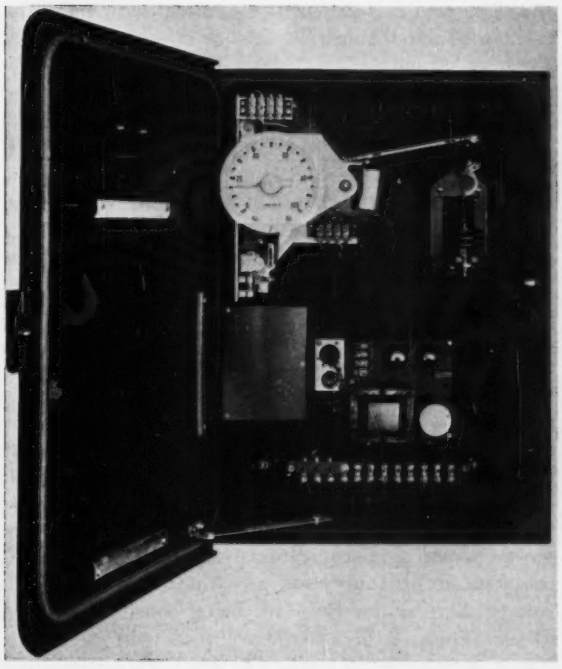
Delegates to the 1959 National Telemetering Conference in Denver, Colo., (jointly sponsored by AIEE) showed by far the greatest interest in mobile telemetering, both with respect to attendance at technical sessions and the accompanying exhibit. Of the 43 exhibitors, only a few showed equipment that could be classified "point-to-point industrial telemetering." Despite the interest shown in mobile telemetering, classical analog methods continued to be used overwhelmingly in small installations of point-to-point equipment, and made up a large portion of the year's telemetering sales volume.

During the year, one of the leading manufacturers of industrial instrumentation marketed three analog point-to-point systems of the current, frequency, and pulse types.

The use of digital telemetering continued to increase, especially in large installations and where supervisory control was also required. Techniques making use of pulse codes seemed to prevail. New and existing supervisory control systems were brought into use to supply pulse code transmission. Since most measurands encountered were of analog nature, a conversion from analog to digital form was required. Generally speaking, two basic methods were used. One involves mechanical encoders positioned by servomechanisms; the other uses a digital voltmeter in conjunction with servos for converting to digital form. The digital output is then transmitted by the supervisory system.



Honeywell's tubeless industrial frequency-type telemeter for central station use in telemetering tie-line power, total station generator, and load-frequency intelligence. Plug-in units provide an easy method of changing transmitter frequency and receiver output and are convenient for servicing. Converts millivolts or current to frequency. Uses 5 to 15 cps or 6 to 30 cps.



Bristol's series 500MS Dyna-Servo Transducer is a high-precision, high-torque electronic unit for converting a small motion into a shaft-position to operate transmitting slidewires, alarms, digital encoding devices, etc. Equipped with a pressure or a differential-pressure sensing element, it has already found wide use in digital telemetering pipeline flow computing devices. The null-balance instrument has an accuracy of ±0.25%; dead-band, ±0.15% of span.

Users of telemetering have shown greater interest in logging during the last year. Digital telemetering techniques lend themselves to logging of data at the dispatch station. Hence, many of the telemetering systems installed terminated in "hard copy," punched cards or tape.

The year also saw a long-time manufacturer of pulse-duration telemetering market a servo-type transducer for sampling quantities such as flow, pressure, and temperature. The device positions digital encoders or slidewires for digital telemetering procedures. The manufacturer also uses the device for introducing analog measurands into their analog computers, and then telemeters the computed values.

Power

INSULATED CONDUCTORS

DURING THE PAST YEAR, further progress was made on the jointly sponsored AEIC–EEI (Association of Edison Illuminating Companies–Edison Electric Institute) research project for the field testing of extra-high-voltage cables and accessories on the Cornell University campus.

The underground portion of the testing station has been completed. This includes complete piping for two pipe-type cables, including manholes and current transformers for loading; ducts, two manholes, and pothead stands for three self-contained cables; thermocouple installation on the pipes and conduits for monitoring cable temperatures; and concrete bases for transformers and other heavy equipment. It is expected that two pipe-type cables and three self-contained cables will be installed or ready for installation about April 1, 1960.

The design of the aboveground portion of the testing station has been completed, and the erection of the station was started in November 1959. Major electric equipment needed for the testing station is either available or has been pledged. Many electric equipment manufacturers, including Joslyn, Ohio Brass, I-T-E Circuit Breaker, Southern States Equipment, and Lapp Insulator, have offered equipment. These companies will furnish extra-high-voltage station equipment as well as necessary equipment for lower voltages. It is expected that preliminary testing and calibration work will be started shortly after January 1, 1960.

The four cable manufacturers and two accessory manufacturers have completed, or nearly completed, laboratory tests on the samples of cables and accessories which they will offer for the Cornell field test. The results of the laboratory tests, including tests on a cable with synthetic tape insulation, have been very encouraging. Based on these laboratory tests, it appears that cable systems will be available which are capable of transmitting 500 mva (megavolt-amperes) or more at 345 kv. It remains to be demonstrated whether such cable systems will remain stable at their initially low dielectric loss levels under actual commercial service conditions. This is an extremely important consideration and the field tests at Cornell are expected to supply an answer to most of the questions which may be raised in this connection.

POWER GENERATION

THE UPWARD TREND in the average size of steam-electric generating units has continued. Three units of 500,000 kw are being built and a unit of 600,000 kw is on order. Sizes larger than this are available and a quotation was submitted for a unit of 800,000 kw.

Two interesting installations with supercritical pressures were completed during the year. Eddystone no. 1 is 5,000 psig (pounds per square inch gauge), 1,200/1,050/1,050 325,000-kw cross-compound, and Avon no. 8 is 3,500 psig, 1,100/1,050 250,000-kw tandem-compound. However, the over-all trend confirms the leveling off in both pressures and temperatures which was evident a year ago. While most installations employ 2,400 psig with temperatures of 1,050/1,000 there is an appreciable number using 2,000 pounds and some using 2,500 pounds with 1,000/1,000 degrees. This indicates a more realistic evaluation of the manufacturing costs and the estimated load factors as well as a reappraisal of the availability of the higher temperature boilers and turbines.

The peaking problem continues to attract serious studies. Diesel and gas turbine-powered units closer to loads have been installed and their costs evaluated. Consideration is being given to the location of low-cost peaking units at central stations.

With the continued decrease of new hydroelectric installations because of the lack of suitable sites, more studies are combining the peaking problem with the use of pumped storage. Recently increased attention has been given to tidal developments.

Further reductions in power plant costs are being made by the elimination of spare auxiliaries, use of turbine drives, new types of busses tying generators to transformers, and closer sizing of electrical facilities.

Considerable progress has been made toward making plants completely automatic and several installations are presently being designed. This subject is being studied from many approaches and basic philosophies are being developed.

Little experience has been gained in the generation of atomic power, other than at Shippingport. However, the extensive studies of both technology and economics now being made plus the construction designs now in process point to a rapid growth of experience in the next several years.

POWER SYSTEM COMMUNICATIONS

DATA TRANSMISSION is a glamour term in this field at this time, and it is primarily concerned with the transmission of intelligence for use in economic load dispatching. Much of this information for direct power operations was formerly handled under telemetering and load control but now with the addition of the "economic" feature, the systems have been materially expanded. Furthermore, the handling of other information such as payrolls, material warehousing, commercial transactions, etc., is progressing rapidly.

Reliability has been the dominating feature of the power system communication channels but now speed is demanding attention. The facilities, consisting of telemetering, teletypewriting, facsimile, telautograph, and television, stand ready to provide economical transmission when the format and the required speed can be determined. It requires close co-operation between the office methods group and the communication engineers to balance data, speed, and cost in determining the most economical system.

Powerline carrier still holds an important position in power system communications. Some of the present problems are in connection with the use of extra high voltage. Several test lines are being constructed upon which extensive high-frequency tests will be made. These include corona, radio, and television interference, and the use of the lines as a carrier transmission medium.

As a result of the increased cost of carrier traps and coupling capacitors and the continuous shortening of transmission line sections, considerable interest has been shown in the use of insulated ground wires as the

carrier transmission medium. Several test installations have been made using both standard power line and telephone line carrier facilities. These investigations open up the field for more economical application and increase the availability of channels. This use of power-line carrier equipment profits in the single-side-band application and also in the use of the broadband coupling in increasing the number of channels that may be applied to a single wire, or pair of wires.

RELAYS

A MAJOR ADVANCE in protective relaying equipment appeared in 1959 with the first full-scale use of static components. Static relays for transmission lines, generators, and feeders were introduced as the forerunners of static relaying in all protective relay fields.

These static relays promise greater reliability and reduced maintenance. They also have lower burden, higher speed, and greater sensitivity.

A new static line-differential carrier-current relaying equipment was developed, field tested, and placed in service on a 345-kv transmission line in the Spring of 1959. Sensitive protection is obtained for all types of faults on practically all transmission lines when combined with certain electromechanical relays. Included are all multiterminal lines, lines having fault currents less than load and lines with considerable mutual induction on ground faults.

A completely static high-speed polyphase generator differential relay was announced. The restraining and operating outputs of the three pairs of differentially connected current transformers are compared in a sensing network. For all types of internal faults, this sensing network output is amplified to trigger a tripping rectifier for breaker trip coil operation

The static time-overcurrent relay offers a flexible device capable of approximating the conventional time curves and having quick reset. One-third reduction in panel space and reduced burden are other features of this new design.

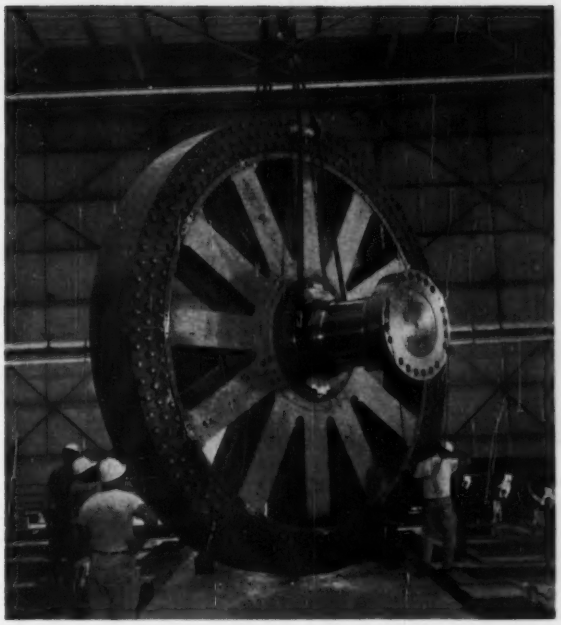
The effect of transient surges on static components at power locations will be a deciding factor in the application of these devices.

A permissive tripping directional comparison relaying system was developed for use with microwave channels for the protection of transmission lines. This combines the best features of the blocking and transfer trip systems to provide faster and more complete protection than previously available.

ROTATING MACHINERY

A MILESTONE IN HYDRO GENERATION was reached with the award by the Bureau of Reclamation of the contract to Allis-Chalmers for the generator to fill the last remaining vacant bay in Hoover Power Plant. When this final 100,000-kva, 16.5-kv, 180-rpm unit goes into operation in 1961, a quarter of a century will have been spanned since the initial unit started commercial operation in October 1936.

Vice-President Richard M. Nixon was principal speaker at a dedication ceremony on October 10, 1959, at The Dalles Dam Project on the Columbia River in Oregon. The occasion was the starting of the 10th General Electric 82,100-kva Kaplan turbine-driven generator in the plant. Ultimate capacity of the station designed by the Corps of Engineers will be 1,806,310 kva.



This 20-foot diameter, 96-ton flywheel will aid research in thermonuclear fusion. Three of these flywheels, when installed in Allis-Chalmers motor-generator sets, will release stored energy to provide a 200,000-kw pulse of d-c power to the C Stellarator, thermonuclear fusion reaction device now under construction at Princeton, N. J.

Applying large vertical generator rotor construction in another field, Allis-Chalmers has built three 20-foot-diameter, 96-ton flywheels with laminated rims. Assembly of the flywheels at the site in Princeton, N. J., solves shipping problem and permits larger diameter with less weight to provide necessary stored energy. Flywheels are for use on three Allis-Chalmers motor-generator sets capable of supplying a total of 200,000 kw of d-c power to the *C* Stellarator, thermonuclear fusion research device under construction at Princeton.

Developed by General Electric, a system for continuous direct indication of stator-winding hot-spot copper temperatures for large turbine generators makes use of special transformers to isolate resistance temperature detectors, which are at high voltage, from indicating instruments mounted external to the generator.

Silicone rubber stator-coil insulation has been extended into the higher voltage range by Allis-Chalmers with the construction of an 11,000-volt synchronous motor now in service. Silicone rubber insulation is also being applied on 13,800-volt motors and generators.

Hermetic motors are protected by Westinghouse against over-temperatures by newly developed positive temperature coefficient thermistors. Resistance of these

Mount Hood dominates background at the Dalles Dam Project on the Columbia River in Oregon. On October 10, 1959, General Electric's 10th 82,100-kva Kaplan turbine-driven generator in the plant was started. Ultimate capacity of station designed by the Corps of Engineers will be over 1.8 million kva.

devices remains nearly constant under 100 C but increases 25 times before 120 C is reached. Embedded in stator windings, these thermistors function in a fail-safe circuit to disconnect power when the winding starts to overheat. Application to larger motors is under development.

A submersible pump motor developed by Louis Allis provides the highest horsepower now available in a 4-inch diameter. Maximum ratings offered are 5 hp., single phase, and 7½ hp, three phase, at 3,550 rpm. Stator windings are encapsulated in chemically inert plastisol and are sealed in stainless steel. Thrust bearing has six self-aligning hardened stainless steel tilting shoes mounted in a spherical seat and bearing on a carbon thrust pad.

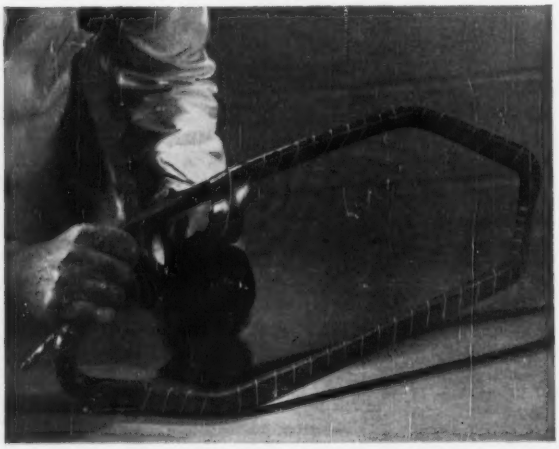


Illustration of the ease with which the total primary insulation wall thickness can be applied to form wound coils with one wrap of Guideline Triangular Tape, a silicone rubber tape made by Dow Corning Corp.

A recent development of the Dow Corning Product Engineering Laboratories is "Guideline Tape." Self-adhering, this triangular silicone rubber tape was designed with particular emphasis on ease of application.

Fabricated from self-adhering Silastic (Dow Corning silicone rubber), a unique material which has the property of adhering and fusing to itself without requiring heat or pressure, Guideline Tape is triangular in cross section and has a colored center line as a guide for precise half lapping. By selecting the proper tape dimension, the desired total insulating wall thickness can be attained with only one layer of tape. Using typical application techniques, Guideline Tape assumes the shape of a flat diamond, thereby facilitating a homogeneous, entirely voidfree insulation wall in just a single wrap. Therefore, labor and time are saved in the insulation of electric equipment.

SUBSTATIONS

THE FIRST SIGNIFICANT USES of digital computers in the substation field were reported during the past year. These include the calculation of forces on bus work

Zig-zag configuration for ring-bus substation design as first used for 230 and 115 kv resulting in over-all saving in cost of steel, insulation, and footings with added flexibility in direction of line take-off, and accessibility for maintenance.

during faults, the design of supporting structures for outdoor stations, the design of grounding grids, and the planning of future substation additions.

Considerable interest is developing in the automatic logging of system operating data either at individual substations or transmitted to a central location. In addition to the usual electrical data, this includes such quantities as temperature, air pressure, and liquid levels—as well as breaker, tap changer, or relay operations.

Increasing usage is being made of highway-type portable spare transformer capacity. Mobile transformers are in service as large as 25,000 kva, 138 kv, three phase, and single phase, 230 kv, 40,000 kva. A complete mobile substation including both high-voltage and low-voltage switchgear on a single trailer is being built rated 115 kv, primary 15,000 kva, three phase.

The design of substation grounding grids is receiving

considerable study with respect to safety and the control of voltage gradients through the earth during system faults. This interest has resulted from a working group report on this subject first published in 1958 which will soon be available in more complete form as a special publication "A Guide to Safety in A-C Substation Grounding."

The following subjects have been of particular interest this year, with further exploration expected:

1. Installation of substations in suburban and metropolitan areas, particularly with respect to appearance, space requirements, and noise control.
2. Co-ordination of phase-to-phase bus clearances with insulation used.
3. Extra-high-voltage substations.
4. Design and installation of aluminum buses and associated connections.
5. Use of aluminum for substation structures.
6. Minimizing station control power requirements, particularly batteries.

SWITCHGEAR

CONTINUED EXPANSIVE DEVELOPMENT and testing of oilless power circuit-breaker types ranked high again in national switchgear activities during 1959. High-voltage gas and air-blast-breaker designs were involved in development and investigation work with new production designs scheduled for numerous 1960 deliveries.

Sulfur hexafluoride (SF_6), already established as a gas-interrupting medium in high-voltage breakers up to 230 kv, 15 million kva, is presently being developed for the lower interrupting capacity breakers down to 34.5 kv. Applications in high-voltage capacitance current switching appear promising with one installation in service at 115 kv.

Medium-voltage and low-voltage air-magnetic circuit breakers and accompanying metal-clad structures remain very popular. Weather-proof aluminum switchgear housings were offered. Epoxy and glass polyester materials as laminates and coatings continue to find more application particularly in this type of switchgear because of tracking and moisture-resistant, flame-retardent, and high electrical and mechanical strength properties. More user interest in stored-energy mechanisms for both air-magnetic and distribution-type oil circuit breakers has led to releases of many new designs and continued improvement in existing units in the 5–15-kv class. One-million-kva 13.8-kv units with a stored energy closing mechanism were scheduled for installation during 1959. Several manufacturers have extended their distribution oil breaker line with stored energy mechanisms to 500,000 kva at 600 and 1,200 continuous current ratings. Extension of standard 600-volt low-voltage switchgear to interrupting capacities of 75,000 and 100,000 amperes with continuous current ratings up to 4,000 amperes was announced.

Continued demand for high-voltage oil circuit breakers rated to 20 million kva interrupting capacity was evidenced by comprehensive test programs, in both American and European laboratories, to demonstrate adequacy of interrupter and mechanism modifications. Several manufacturers firmed breaker-interrupting ratings to 20 million kva at 230 kv through successful high-voltage laboratory and field tests.

In keeping pace with user switchgear demands, most manufacturers initiated expansion of laboratory facilities in 1959, including opening entirely new or relocated test installations.

Automatic circuit reclosers and line sectionalizers have undergone concentrated development aimed to fit the present tendency of utilities to apply these devices on distribution and substation applications.

Of interest to users of isolated-phase bus was the introduction of a high-voltage air or compressed-air switch design to be completely metal-enclosed and integrated within the bus run.

SYSTEM ENGINEERING

THE AIM OF SYSTEM ENGINEERING is to develop means whereby electric power companies can lower over-all cost and increase service reliability by improved planning, design, and operation. Significant progress in that direction has been attained during the past year by combining more precise analytical techniques and modern computational methods with new equipment and improved design of system components.

An adequate program for the economic dispatch of power requires reasonably accurate incremental costs. Earlier work on incremental heat rates of generating units has been supplemented by similar studies on incremental maintenance costs.

Several recent technical papers indicate a renewed interest in the use of probability mathematics in determining system requirements. To encourage further acceptance of this concept, a committee report has been prepared which analyzes, compares, and clarifies earlier investigations in this field.

Improved computational techniques have been introduced for determining programs for the economic dispatch of generation including the important factor of system losses to the point of use. Greater use is being made by operating companies of specialized computing devices to perform this function with various degrees of automation.

Interest in the application of modern, general purpose computers to the problems of system engineering has been growing at an encouraging rate. New computing devices are available with a wider range of characteristics to make them more suitable for the computing requirements of electric utility engineers. While programs are being developed at an ever-increasing rate, the availability of programs for most repetitive system problems has also improved. An engineering department with low machine use can readily obtain machine time at established computer centers. Several electric utilities have substantially increased their use of computers for engineering, and others are seriously considering such a move as recent progress in this field has removed previous objections to conversion.

TRANSFORMERS

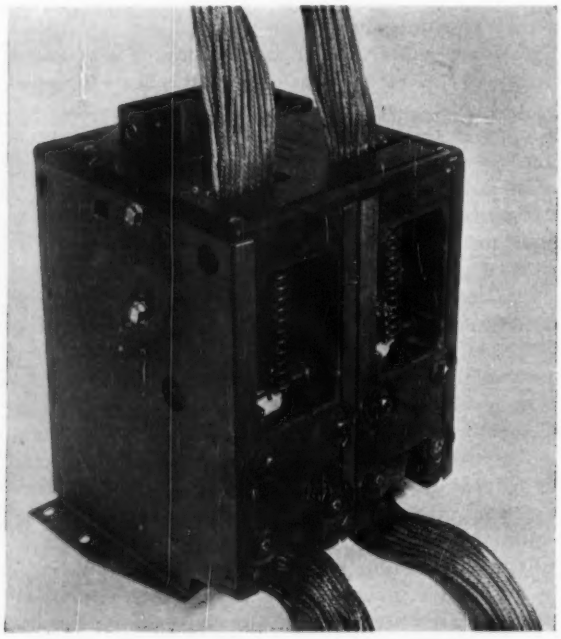
DEVELOPMENT WORK AND COMMERCIAL APPLICATION was advanced in 1959 on gas, gas-vapor, and vapor-insulated transformers. Several units are now in commercial service and more are planned for 1960. The use of lower levels of insulation has aided in applications at voltages of 115 kv and possibly higher. Development of an economical gas or vapor-insulated transformer can lead to safer installations, particularly in congested districts.

Pennsylvania Transformer Co. announced application of transformers with phase-isolated load-tap changer which allows control of each phase voltage separately. Units are available up to 9,375 kva at 110-kv BIL (basic impulse insulation level).

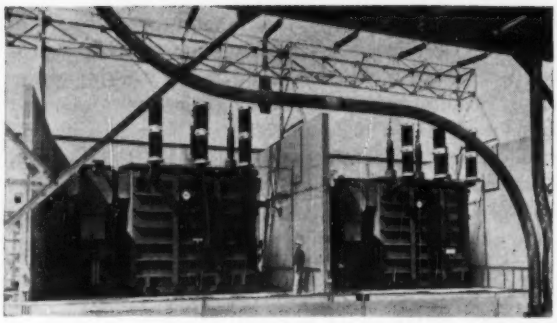
Wagner Electric presented the application of automatic, stepless-load ratio-control transformers and regulators.

Several dual-cooled transformer banks were installed by Allis-Chalmers. In a typical case, the rating of one 90,000-kva unit of a bank of two was increased to 120,000 kva by adding the cooling system of the idle transformer.

The Permalex insulation system was introduced by General Electric. This and the Insuldur insulation system introduced by Westinghouse promise to give increased insulation life at higher operating temperatures on oil-insulated transformers. These developments will give the operator greater latitude in handling overloads.



View of circuit breaker, new in size and design, developed by Westinghouse. It is an exceptionally heavy-duty type, and will be used up through the 250-kva, 480-volt design. The new features are designed around the principle of all-electric control. Mechanism trips electrically, and recloses electrically, so that either manual or automatic control is obtained by single relay mechanisms.



Courtesy Allis-Chalmers

Installation view of 90,000/120,000-kva FOA dual-cooled power transformer rated 132 kv to 14.1 kv with ±10% LTC-TLB.

Three-phase potential transformers using the solid-insulation principle with insulation reduced at neutral were introduced by Westinghouse Electric in the 550- and 650-kv BIL ratings. These units meet the same requirements as three single-phase units, but with reduced weight and cost. Any one or two phases may be used with the other(s) disconnected.

TRANSMISSION AND DISTRIBUTION

THE PRESENT and anticipated future requirements for increased transmission capacity have continued to stimulate research in the field of extra-high-voltage transmission. Design was completed and construction started on a prototype a-c transmission system for voltages from 460 to 750 kv. Elsewhere, studies during 1959 encompassed a wide range of related subjects, including consideration of nominal standard voltage levels above 230 kv, proper clearances to be associated with various voltages, and the electrical characteristics of bundled conductor arrangements. Corona and radio influence factors were studied, with particular attention being given to instrumentation and field measurement methods.

The phenomena of conductor vibration were further explored through greatly improved and newly developed techniques for field measurement and data correlation. Research and development on conductor materials continued, particularly with respect to alloy strengths, strand configurations, and environmental factors. Attention was directed toward the use of wood, as well as steel, for extra-high-voltage structures. The strength requirements of transmission structures, in general, were considered in the light of the experience of utility engineers who reported on broken wire assumptions used in line design.

In another area, switching surges were the subject of detailed investigation, and conclusions were reached with respect to surges of the line-to-ground type. Insulation requirements continued to receive attention, both for lightning and for power frequencies.

In the field of distribution, attention was given to improved methods of protection for distribution circuits, to grounding practices, and to means for carrying

primary and secondary circuits through areas where trees or impaired clearances constitute problems. A draft of a proposed new standard for power capacitors was completed, and the application of computers to distribution design was further explored.

Other studies included work on arc deionization time, system stability, and the preparation of bibliographies on subjects in the field of transmission and distribution.

Science and Electronics

COMPUTER DEVICES

WHILE HUNDREDS OF DEVELOPMENT GROUPS and thousands of application groups have made significant advances in almost as many different fronts, the year 1959 will be best remembered for the following events:

The industrial control computer arrived. Long talked of, and with a few substantial installations already proving out, the year saw widespread acceptance and very great advances in this area.

For example, the Texas Company 1,800 barrel per day polymerizer installation was the first full-scale process placed under closed-loop computer control, followed by others at B. F. Goodrich Chemical Co., Monsanto Chemical Co., and Jones & Laughlin Steel Corp.

Adaptive control received great impetus. It recognizes the computer capability of determining improved parameters for a regulating or control system while in operation, and provides for adjusting accordingly.

Computer design by computer took on real significance. Not only were computers simulated for check out of instructions codes, but the complete wiring and component location specifications and diagrams were computer produced.

In manufacturing applications, greatest progress was in manufacturing information and production control, with a job shop simulator receiving special attention.

On-line computers with large random access memories multiplied rapidly in businesses of all kinds as well as in system operation, with communicating data links tied in directly in both cases.

Nearly all major computer manufacturers brought out fully transistorized models during the year.

The Parametron appeared as a new logical element in various forms with the diode version going to megacycle pumping frequencies, and about a megacycle signal switching.

The Esaki or tunnel diode was announced giving promise of most of the characteristics desired in the next generation of logic elements, from low cost and high reliability to extremely high speeds (one millimicrosecond switching time).

Serious work began on universal language programming research to aid in exact communication of logical processes and to avoid the problem of reprogramming problems for different machines. Also, there was great progress in both business and scientific compiler programs and systems for various computers.

The Perceptron of Cornell Aeronautical Laboratories is symbolic of the general interest in "learning machines" that are "trained" rather than "programmed."

Several educational institutions have completed well-rounded advanced curricula in computers and information processing.

The first International Conference on Information Processing met in Paris, France, June 15-20, 1959, under UNESCO sponsorship, and a World Federation of Computing Societies was formed; AIEE participated in both of these historic events through the Joint Computer Committee where it acts co-operatively with IRE (Institute of Radio Engineers) and ACM (Association for Computing Machinery).

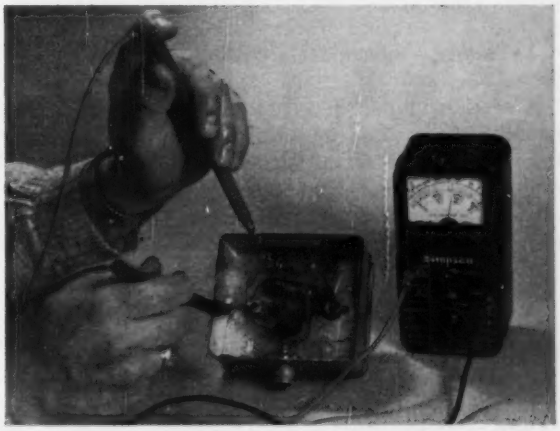
ELECTRICAL INSULATION

DIELECTRIC GEL is a new silicone dielectric developed by Dow Corning Corp. for use as a potting compound. Supplied as a liquid (with a catalyst), Dielectric Gel offers excellent properties and unique advantages that solve a variety of electronic design problems.

Once in place, heating converts the liquid to a resilient, jelly-like, crystal clear mass that protects components and equipment from moisture, shock, vibration, and other damaging environments. Since no mechanical stresses occur upon curing, Dielectric Gel is ideally suited for potting such delicate components as magnetic amplifiers, vacuum tubes, and semiconductor devices.

After curing, Dielectric Gel is dimensionally stable and will not revert to a liquid even when confined at high temperatures. It is physically self-healing and permits both visual and instrument inspection of potted circuitry. In fact, instrument test probes inserted into Dielectric Gel do not impair its ability to provide environmental protection, because upon removal of the probes, Dielectric Gel reseals itself.

Dielectric Gel has the extremely low dielectric loss characteristic of electrical grade silicone fluids. Physical and electrical properties of the material are retained after long exposure at temperatures up to 200 C.



Test probes inserted through Dow Corning's unique Dielectric Gel illustrates self-healing characteristics.

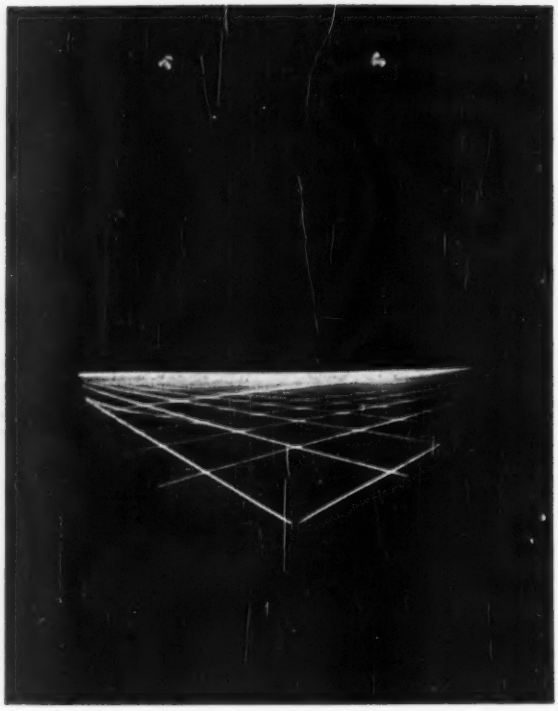


Photo of oscilloscope display produced by a simplified version of General Electric's electronic contact analog generator.

ELECTRONICS

MAJOR ADVANCES in the electronic art during 1959 included the following:

1. Parametric amplifiers have been successfully operated in military and scientific communication equipment. Parametric amplifiers using semiconductor diodes have been operated up to frequencies of 10 kmc (kilomegacycles).

Tunnel diodes, invented in Japan, have been made and successfully operated in electronic switching circuitry. These devices are very inexpensive and useable through a wide range of temperatures.

Twistor-type memories have been perfected and simplified.

A new discipline, "molecular engineering," has been established aimed at the creation of functional electronic circuits performing the composite job of several components in "monolithic blocks."

"Self-adapting systems" based on the study of biological mechanisms have been studied and devised.

2. In the field of information display, an instrument called the Contact Analog Generator has been developed as part of the Army–Navy Instrumentation Program. The instrument responds to changes in the relative position and attitude of the aircraft and the ground. It accepts inputs from a variety of sensors and a central computer, operates on these, and generates signals that are supplied to a display device. As the plane changes altitude, velocity, roll, pitch or heading, the picture changes correspondingly, and the pilot can see his relationship to the ground.

The present device shows the earth as a flat surface. A more advanced version, to be test flown within a year, will show real terrain—hills and valleys—as well as man-made obstacles, in addition to a "roadway" in the sky.

MAGNETIC AMPLIFIERS

MAJOR ADVANCES in magnetic amplifier technology during 1959 were made in the area known as computer magnetics. A variety of new devices using nonlinear magnetic characteristics to accomplish logic or memory functions were introduced or improved upon during the year. Often, new words were coined to describe these devices and names; "Parametrons," "Transfluxors," "Twistors," "Biax," and "Mad" devices are now in common usage. The guiding force behind these developments is the search for digital storage and computing equipment which exhibits improved reliability, power economy, insensitivity to environmental conditions, and economy of size and weight. In many instances for specific portions of computer circuitry, it has been found that the functional replacement of transistors with the appropriate nonlinear magnetic devices results in the desired improvements and often with a decrease in cost.

The forms of these new devices are in some cases radically different from the conventional toroidal-core magnetic amplifier. Some of the more unusual shapes include multiaperture ferrite plates and multiple-layer buildups of evaporated films where alternate layers may be insulators, conductors, or magnetic films. Evaporated magnetic film core memories have been built having switching times in the millimicrosecond range and complex multiaperture ferrite core devices have been built which will perform the logic operations required in a digital computer without the use of any transistors or diodes.

Another area of magnetic amplifier technology in which recent advances have been made is in combination with the controlled rectifier or solid-state thyratron. Several types of equipment such as regulated power supplies, a-c and d-c motor speed controls, and static inverters, which use small magnetic amplifiers to modulate controlled rectifier power stages, have been developed and marketed. One rather unusual but major application of the controlled rectifier has been in light dimming equipment—once the forte of the magnetic saturable core reactor.

SEMICONDUCTOR METALLIC RECTIFIERS

IN BOTH LIGHT AND HEAVY EQUIPMENT, the silicon rectifier continued to supplant the earlier semiconductor types as well as the mercury arc tube. For example, the mining industry in 1959 saw the introduction of silicon portable mining equipment featuring both unregulated and regulated designs. Unregulated silicon units offered greater simplicity, higher efficiency, and a smaller 2-car design. They also featured an over-all height fully 12

inches lower than any mercury arc units previously offered. These unregulated portable miners can now replace the unregulated glass bulb rectifiers which many mines have been using.

In other industries, the orderly introduction of silicon rectifier equipment continued replacing other conversion means. Silicon rectifiers were delivered to equip the cleaning and plating sections of a full-scale strip-steel processing line. In order to gain operating experience, the aluminum industry accepted two prototype silicon units for installation on existing pot lines. A silicon unit was purchased to operate in parallel with a mechanical rectifier in a chlorine line. Various units were delivered for other industrial applications, notably arc-furnace power supplies, general shop d-c power and special high-power testing supplies.

A number of interesting case histories were reported in 1959, pointing up the savings possible with semiconductors. A large South African mining operation, for example, realized savings over 50% after its battery-driven locomotives were converted to a-c supply by the installation of semiconductor rectifiers and auxiliary equipment. All of the change-over apparatus fit right into the old battery boxes after d-c controls and batteries were eliminated. The conversion necessitated installation of overhead trolley wires, but its cost was more than offset by the savings and efficiency provided by the semiconductor rectifier equipment.

The year 1959 also marked the use in high-voltage radar power supplies of silicon rectifiers. Both oil-cooled and air-cooled silicon units were used in this critical equipment which was rated at 40 kv, 21 amperes. Additional silicon rectifiers of 1,000 kw rating were delivered for 250-volt industrial service.

Serious exploitation of the silicon controlled rectifier was another major development in 1959. Devices rated 3 through 16 amperes became available in quantity from several manufacturers. Larger silicon-controlled rectifiers rated at approximately 50 amperes were placed in pilot production. In addition, some equipment appeared that utilized the smaller units. For example, these rectifiers were incorporated as switches for firing squibs (military devices), in control equipment for theater lighting, and in adjustable field supply on a paper-making machine. In the laboratory, developments in new power circuits and firing circuits foretell greatly increased use of the silicon-controlled rectifier in years ahead.

SOLID-STATE DEVICES

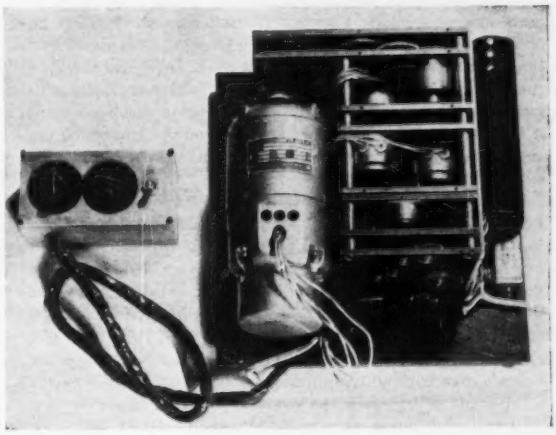
A SIGNIFICANT DEVELOPMENT in thermoelectric power devices during the past year was the 100-watt generator constructed for Rome Air Development Center by the Westinghouse Electric Corp. This generator operates from propane gas with an over-all conversion efficiency of 5%. The heat sink is free convected air with a special fin design that minimizes weight; consequently, the total generator is 50 pounds, exclusive of fuel.

The generator is designed to supply power in remote areas not serviced by power lines. For example, a practical civilian application would be cathodic protection of pipelines or power for pipeline communication equipment.

This development is a step toward high-power high-efficiency static power supplies which serve in the future as important sources of auxiliary electric power.

The year 1959 has also seen the tunnel diode become an interesting reality. This device was invented by Dr. Leo Esaki of the Sony Corporation of Japan in the year 1958. The tunnel diode operates by means of quantum mechanical tunneling through the energy barrier imposed by the band gap of the semiconductor material of which the diode is formed. This transition takes place at the speed of light, and consequently, high switching speeds are possible using this device. Some of the potential uses of the tunnel diode are microwave oscillators and amplifiers and ultra-high-speed computing switches.

15-Speed Transmission



A rugged, compact transmission featuring 15 accurately controlled speeds and extremely high torque has been designed and developed by Dynamic Gear Company, Amityville, N. Y.

The 15 speeds, ranging from 3.3 rpm to 7,812 rpm, are electronically controlled by the use of magnetic clutches with desired speeds obtained by mere dialing. No manual shifting of gears is necessary. Torques developed at the various speeds range from 50 ounce-inches to well over 100 ounce-inches.

The input motor is reversible and will deliver the aforementioned speeds and respective torque in either direction. The motor speed is self-governed and accurately maintained at 8,500 rpm. Units operate on 115 volts, 60- or 400-cycle current.

Typical applications are for recording instruments such as oscillographs and other recording devices requiring constant and precise speeds. It can also be used as a laboratory device for testing servo packages.

Professional Registration

N. L. FREEMAN
MEMBER AIEE

A review of the factors that create the need for professionalism in engineering. Such status can only be achieved, as in the legal and medical professions, by the unselfish service and attention each man owes to his profession.

THE TIME was 1907. The place was Cheyenne, Wyo. Neither Wilma Lang, assistant secretary of Wyoming Board of Examining Engineers, nor I was there. However, she has access to the records and, in 1957, told in the following manner, what happened years before:

> "The wild west wind was blowing snow from the open plains of Wyoming against the windows of the state engineer's office in Cheyenne. But it was not the January weather, 50 years ago, that made Clarence T. Johnston shudder as he opened the morning mail. The young state engineer was examining the back of a large piece of oil cloth. On it was sketched the cross-section of a ditch, identified as a 'Map to File Application for Last Chance Irrigating Ditch.' Upon turning it over, it became apparent the map was drawn on the reverse of the engineer's tablecloth, with dried splatters of egg and coffee still evident on the surface.
>
> "Looking around the office, the state engineer shook his head. Where was he to file the tablecloth? Only the month before the same engineer posed a similar problem when he sent in plans for a small reservoir on a paper sack. Not only were there great irregularities in the size of the so-called maps, but they were often sworn to as being correct when not even based on surveys.
>
> "In 1907 there was nothing in the law to distinguish between a man without qualifications and an engineer who made a life study of his work. An engineer, desiring to represent a project in Wyoming to best advantage to eastern investors, was tempted to make his maps show more land in a proposed irrigation project than could ever be reclaimed. Thus, from the inaccuracies and inconsistencies of maps filed in the state engineer's office, came the inspiration for creation of America's first state board to examine and register professional engineers and land surveyors."

C. T. Johnston drafted a bill which, on February 20, became "Chapter 86, 1907 Session Laws of Wyoming." It contained provisions for employment of assistants to the state engineer, amendment of irrigation laws, and creation of a 3-member board of examining engineers to serve without compensation.

PUBLIC PROTECTED

IN THIS DRAMATIC FASHION, Wyoming put into use an old principle, then new to the field of engineering. Thereafter, for the protection of the public, the practice of engineering was regulated by statute. Many years were to pass before all states did as Wyoming had done and restricted the practice of engineering only to those who were legally certified as qualified. Yet, it is obvious that the movement thus begun followed a long-established tradition and one for which no satisfactory substitute yet has been found.

When a substantial danger or threat to public health, welfare, property, or safety is believed to exist, the public usually acts to protect itself. If this be in a professional field, it is customary to restrict practice in that particular area only to those who have legally established their qualifications. Then, those who wish to practice must obtain license to do so. Whether we use the term license or registration, it is certification of qualification in advance of practice.

The initial unfortunate engineering experience in Wyoming on its vast irrigation program comprises only one example of the many errors and tragic mistakes in the works of men. Frequently, they have been due to incompetent engineering. Clearly, professional registration does not offer a complete cure for this. But it has reduced and in the future will keep at a minimum the number of failures due to faulty engineering. This is achieved by limiting the practice of engineering only to those who satisfy the qualification requirements for registration.

Many important professions are so restricted and regulated by law. However, not all of them may be called learned professions. Broadly speaking, when special professional training is required somewhat beyond the undergraduate training of a liberal arts program, we consider it to be a learned profession.

PROFESSIONAL LIFE DEFINED

THE REGISTRATION OF PRACTITIONERS is certification of their qualifications in advance of practice. It means that those permitted to practice have satisfied established, minimum standards. Further, it is authorization to do something and, figuratively, opens a door to a professional career. That brings up the question, "What is professional life and endeavor?" According to Wickenden, there are some four viewpoints on the subject. It may be called an attitude of mind, a kind of work, an order in society, or a fiduciary relationship between client and practitioner. In a measure, a true professional man partakes of all of them.

In 1934, while addressing the 30th Annual Congress on Medical Education, Licensure, and Hospitals, Dean Justin Miller of Duke Law School made several significant observations. Two of them are directly quoted:

A special article recommended for publication by the AIEE Registration of Engineers Committee.

N. L. Freeman is secretary, Board of Examiners, The University of the State of New York, Albany, N. Y.

"It is said that in former ages the general level of intelligence was so low that lay people were actually at the mercy of members of the learned profession. Today though, the general level of intelligence has moved up appreciably; the content of knowledge in the professions has, perhaps, increased even more greatly. It is a matter of necessity, therefore, not of choice, that the control of licensure is delegated to members of each profession. No one else knows enough about the science and the art involved in each case to insure to those outside the profession the benefits thereof, on the one hand, and the protection from spoliation on the other Normally this delegation of authority indicates a confession of inability adequately to determine the qualifications of desirable new members of the various professions and faith that the leaders of the professions will establish and maintain such standards as will insure the benefits thereof and prevent the spoliation which might otherwise occur."

At this point, I must re-emphasize what Dean Miller said in this quotation. Clearly, it is more than tradition that requires a profession to run itself and to determine who is qualified to practice. It is a practical necessity. Again, quoting Miller:

"One way of testing the nature and extent of that obligation is to consider the difference between a profession and a business. In business transactions each participant is assumed to be equally well informed and equally able to hold his own in the give and take of trade and barter. The well-known maxim of the law warns: 'Let the buyer beware.' On the other hand, the member of a profession is assumed to be better informed than the client or patient whom he serves, and stands in the position of champion or protector."

Thus, the pattern is established. The major obligation of a profession is to serve and protect the public. A profession is given the exclusive right to practice in its field. It is expected to determine who is qualified for practice and who should be rejected as not qualified. The profession must police itself. It is believed that the public will be served best in this manner.

QUALIFICATION REQUIREMENTS

IN RETURN for what is the equivalent of a franchise, the public expects, as it should, competence, ethical performance, and protection from bungling and extortion. Nor is that the complete specification. It is from these concepts that the qualification requirements for registration have been developed.

Throughout the country, the requirements for registration are for the same general purpose. Of course, they are not all identical. Each state has shaped its requirements around what were believed to be its particular needs.

A certain minimum age is specified in each statute. It varies from 21 years to 25 years. It is there as a partial measure of maturity. A professional person should be a mature individual and age is considered to be one of the important dimensions of maturity; hence the yardstick of years.

A professional person is given a special place in the courts. His standing in the community often carries with it special recognition and obligations. In short, a professional man possesses a special form of citizenship. Many states believe that legal citizenship is an inherent component of this special citizenship and, for this reason, have made citizenship a requirement.

Professional attitude is given further dimension by requiring the applicant to be of good moral character. This is a very difficult factor to measure positively. Nevertheless, integrity is a keystone of a profession and an effort must be made to evaluate this intangible quality in every applicant.

An all-important, distinguishing characteristic of a profession is the special body of knowledge needed by its practitioners. Prerequisite to an understanding of engineering is a satisfactory secondary school education. Then follows formal, technical training in an accredited engineering program. The completion of such a program is not sufficient, for students seldom are mature engineers ready for unrestricted and unsupervised practice. In order to develop and mature a graduate's engineering knowledge and judgment, most statutes require an internship under the preceptorship of older engineers. Such postgraduate training constitutes further education in the application of engineering principles. Usually, the internship is at least 4 years in length and it must consist of experience of a grade and character satisfactory to the board.

After all of these requirements have been satisfied, the applicant may be admitted to the licensing examination, the final test of fitness to practice. At this point, the examining board is concerned with how well a candidate applies what he knows, rather than what or how much he knows. Hense, most professional engineering licensing examinations are open book.

In other words, certification that an applicant has earned a degree in an accredited program ought to be sufficient evidence that he has been taught the technical knowledge required in order to practice engineering. Some of us believe this should be accepted at face value; that a re-examination of education which resulted in a degree in an accredited program is not justified. Others of us insist, and rightly so, that graduates of accredited engineering curricula are not uniformly of the high quality we should expect. Further, the results of the written examinations show that they are not. So, while the examination must be designed as a measure of fitness to practice and should be an endeavor to measure an applicant's ability to use what he knows, we cannot overlook the fact that some degree of educational testing most likely will enter into it.

In the past 15 years, there has been another major development in connection with examinations. I refer to the preliminary examination by which the newly graduated may become engineers-in-training. Under this arrangement, part of the full licensure examination may be taken before the graduate acquires practical experience. Upon passing it, he is certified as an engineer-in-training. Obviously, an examination taken before practical experience has been acquired does not measure so well one's fitness to practice. However, if properly constructed, the examination can be a good test of the applicant's ability to use what he knows. Also, it introduces another important factor. Of all

unregistered or unlicensed people, the engineer-in-training is most conscious of professional status and recognition. He knows he has a part in it and has something to look forward to in that regard.

WEIGHT OF EXPERIENCE AND SPECIAL CONDITIONS

THE QUALIFICATION REQUIREMENTS enumerated—age, citizenship, character, high school, formal technical training, a postgraduate internship, and a formal examination of fitness to practice—would seem to be straightforward enough. Unfortunately, it doesn't work out that way.

Right away we must take into account the fact that many people, without formal engineering education, occupy engineering positions and do very well in them. They are, in a way, "self-made engineers," and we cannot deny that they exist. Therefore, all engineering statutes permit an applicant to substitute additional years of practical engineering experience for whatever he lacks in formal, technical training. In some states, one may even substitute many years of experience for the written examinations. However, this arrangement is less prevalent than it once was.

Also, some states permit examinations to be waived under certain special conditions. For example, most will accept, in lieu of their own, the equivalent written examinations of other states. A re-examination of an applicant who has already been adequately examined is neither necessary nor justified.

Then, some states have an eminence provision, under which some qualification requirements may be waived on the basis of what our colleagues in the medical profession call, "Eminence and authority in the profession."

I do not think we should overlook the fact that the engineering statutes of practically all states specify certain exempted activities. As my old friend and former fellow board member, Dr. D. B. Steinman, put it, "These are activities which do not require the services of a professional engineer." Regardless of the reason for an exemption, this is the only possible interpretation which can be given to that part of the law.

NAIVETE OF ENGINEERS

NOW I COME TO AN OBSERVATION which probably will not win any friends. Many engineers, although exceedingly competent technical people, appear to be incredibly naive with respect to professional registration. This, in itself, seems incredible for engineers and scientists have been found to comprise the group possessing the greatest intelligence. This fact was uncovered during World War II, when 12 million servicemen were tested.

Nevertheless, engineers appear to be either very gullible or exceedingly susceptible to incompetent opinions and poor guidance of others with respect to registration. If it be a case of "the blind leading the blind," most of them seem to prefer to be the ones who are led. Often, they even endeavor to substitute desire or opinion for definitions and requirements spelled out positively in a law.

In fact, engineers seem to think they have a choice in the matter. They do not, if they want to be legally identified as engineers. And very few state laws allow any discretion beyond the specified exemptions.

Yet, even now we encounter new applicants who, finally becoming aware of a registration law, insist that the statute must be adjusted or must be interpreted to fit their particular qualifications. Usually, this means that a "grandfather provision" should be resurrected in their behalf. True, a "grandfather clause" is necessary in every initial professional statute. But, after a reasonable but brief period, it must be removed and it always is. To revive it or its features because some individual or individuals have neglected to take action when they should, would be to turn back the clock.

When so much has been published and said on the subject of registration, licensure, and engineering as a profession, no one now engaged in engineering really can say truthfully that he is unaware of it. Wyoming has had such a statute for 52 years. New York, the 12th state to enact one, has had its law for 39 years. More and more it is becoming fashionable for engineers to obtain legal certification of their qualification to practice. I suppose this indicates a gradual awakening by the engineering population and by the public. It is recognition that licensure is required by law; and, as law abiding citizens, it is incumbent upon each to comply.

A profession is a way of life and the professional attitude is peculiar to it. Just where does the process begin? When does a person decide to become a professional man and how does he go about it? I have supplied some of the answers to these questions but certainly do not know simple ones to all of them. Instead, each of us should do some thinking and some genuine "soul searching" on this matter of engineering as a profession. It is not necessary to figure out a new way to do it, but only to determine what steps should be taken in order to be a part of what is already under way very successfully.

STATUS A REWARDING STRUGGLE

OFTEN WE REFER to what members of the legal and medical professions have accomplished in this regard. Perhaps we should also look at what they had to do to attain the positions of prestige they currently enjoy. Both are now shining examples of what can be done to protect the public and, at the same time, develop a profession. Yet, neither has always had the same fine reputation. The legal profession has acquired much of its luster, prestige, and standing since the revolution of 1776.

Every barber pole is a reminder of the fact that doctors have not always been the well-trained and able physicians encountered today. Most of the medical profession's real strides toward greatness have been made in the past 50 years. Its diploma mills have vanished, medical schools are uniformly good, disease and human ills are now under better control than at any previous time.

And yet prestige and a prominence were not bequeathed to either profession. They were accomplished

by work, the co-ordinated work of a large number of willing members of the profession guided by some excellent and capable leaders.

In a way, registration for engineers provides a similar opportunity and points the way. The leadership and work are jobs for us as members of the profession. I can add very little to that. Perhaps I should close by relating something that happened to me almost 25 years ago.

I came to New York from another state and obtained a job as a consultant, and found that I needed a license as a professional engineer. At the time, I didn't know that there was such a thing. In fact, I had never given the professional aspect of engineering much thought. The activity in which we were to engage was new and my superior was surprised when it was discovered that he also needed a license. After we sent in applications, he remarked to me, "The thing for you and me to do is to obtain our licenses, join the professional society, and get to work in it as professional men." What he had in mind was the unselfish service and attention each man owes to his profession. I followed that advice and it paid off very well. Years ago, before I became affiliated with the New York Board, I called it "the best investment I ever made;" today, a dozen years later, I still feel the same way.

We all know that each person has the job of building his own future from the opportunities presented. William James, the American philosopher, once observed, "Some people never see an opportunity and they never seem to get along." Lest we overlook an opportunity, I repeat to you the same advice given to me: "Obtain license or registration as a professional engineer in the state of your residence, join the professional society, and get to work on the job of building the profession."

Transient Junction Temperatures in Power Transistors

W. W. GRANNEMANN J. D. REESE

Very little information is presently available on transistor junction temperatures for pulsed input waveforms. In the study described, a simple thermal model of a power transistor is assumed and a heat-flow analysis of the model, using Laplace transforms, is made.

DESIGN ENGINEERS are often severely hampered by the lack of information on power-dissipating capabilities of power transistors when operated with various input waveforms. Manufacturers usually give only d-c power ratings and, occasionally, a method of approximating pulsed-input ratings. While these approximations are usually valid for the wider pulses, they are often inaccurate for narrow pulses. The exponential approximation usually used often restricts the peak pulsed-input power to too low a value for the narrower pulses. A considerable increase in peak power over that recommended by the manufacturer's approximation is possible if sufficiently narrow pulses are used.

In analyzing the heat flow in a power transistor a simple one-dimensional heat-flow model is assumed. Fourier's equation for heat flow in this model is solved for the crystal temperatures by the use of Laplace transforms.

We first obtain an expression for the crystal temperature in the transform domain for any input waveform for which the transform exists. We then obtain an expression for the junction temperature as a time function for the repetitive rectangular pulsed input. An approximate expression for the maximum instantaneous junction temperature is derived from this expression.

As a check on the theoretical investigation, measurements of the instantaneous junction temperatures were

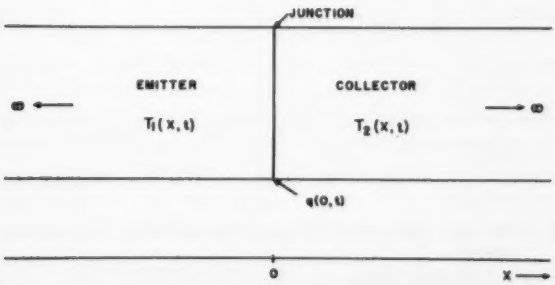


Fig. 1. The thermal model.

A special article recommended by the AIEE Solid-State Devices Committee.

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made for the same pulsed conditions. A common base circuit was used for experimental measurements. Collector reverse-leakage current was used as the indicator of the junction temperature.

THE THERMAL MODEL

THE EXACT THERMAL MODEL for an alloyed-junction power transistor is extremely difficult to analyze. Several simplifying assumptions can be made, however, if approximate results are acceptable.

The first of these assumptions, that radiation, convection, and conduction through the gases surrounding the crystal are negligible, is easily verified by a few simple calculations.[1,2] This assumption reduces the three-dimensional model to a one-dimensional model.

If we further assume that the emitter and collector can be represented by semi-infinite slabs of identical homogeneous material, we obtain the thermal model shown in Fig. 1.

This semi-infinite slab assumption may appear crude. However, as is shown in Fig. 2, it is a good approximation for the narrower pulses. Curve 2 in Fig. 2 is the unit-step response for a thermal model with semi-infinite emitter and collector. Curve 1 is the unit-step response for an electric analog.* These two curves are essentially the same for any time less than 0.02 second. Thus, for any pulse less than 0.02 second in duration, the semi-infinite slab approximation is very accurate.

HEAT-FLOW ANALYSIS

FOURIER'S HEAT-FLOW EQUATION for our one-dimensional model may be written as

$$\frac{\partial^2 T\ (x,\ t)}{\partial x^2} - \frac{1}{\alpha}\ \frac{\partial T\ (x,\ t)}{\partial t} = 0 \qquad (1)$$

where

$T\ (x, t)$ = crystal temperature in degrees C

$1/\alpha = RC$

R = reciprocal of thermal conductivity in centimeter–degree C–seconds per calorie

C = thermal capacity per unit volume in calories per degree C per cubic centimeter

For our model the following boundary conditions are applicable:

1. $Rq\ (0,\ t) = \dfrac{\partial T\ (0,\ t)}{\partial X}$

2. $T\ (x, t)$ remains finite as $X \to \infty$

Since our model is symmetrical about the junction ($x = 0$), we need only analyze the heat flow in half of the model. Our analysis here will involve the portion of the model to the right of the junction in Fig. 1.

If we assume an initial temperature of T_0 and take the Laplace transform of equation 1 with respect to time we obtain

$$\frac{\partial^2 T_2\ (x,\ s)}{\partial x^2} - \frac{1}{\alpha}\ sT_2\ (x,\ s) + \frac{T_0}{\alpha} = 0 \qquad (2)$$

Taking the Laplace transform of equation 2 with respect to distance yields

$$P^2\ T_2\ (p,\ s) - \frac{s}{\alpha}\ T_2\ (p,\ s) + \frac{T_0}{\alpha\ p} = p\ T_2\ (0,\ s) + \frac{\partial T_2\ (0,\ s)}{\partial x} \qquad (3)$$

Solving equation 3 for $T_2(p, s)$, expanding by partial fractions, and taking the inverse Laplace transform with respect to p yields

$$T_2\ (x,\ s) = \frac{T_2\ (0,\ s)}{2}\left(\epsilon^{-x\sqrt{s/\alpha}} + \epsilon^{x\sqrt{s/\alpha}}\right) + \sqrt{\frac{\alpha}{s}}\ \frac{\partial T_2\ (0,\ s)}{2\ \partial x}$$

$$\left(\epsilon^{x\sqrt{s/\alpha}} - \epsilon^{-x\sqrt{s/\alpha}}\right) - \frac{T_0}{2s}\left(\epsilon^{-x\sqrt{s/\alpha}} + \epsilon^{x\sqrt{s/\alpha}} - 2\right) \qquad (4)$$

Applying boundary condition 2 to equation 4 results in

$$T_2\ (0,\ s) = \frac{T_0}{s} - \frac{\partial T_2\ (0,\ s)}{\partial x}\ \sqrt{\frac{\alpha}{s}} \qquad (5)$$

By substituting $T_2\ (0, s)$ from equation 5 into equation 4 we obtain

$$T_2\ (x,\ s) = -\sqrt{\frac{\alpha}{s}}\ \frac{\partial T_2\ (0,\ s)}{\partial x}\ \epsilon^{-x\sqrt{s/\alpha}} + \frac{T_0}{s} \qquad (6)$$

Using boundary condition 1 and replacing α with $1/RC$, we may write equation 6 as

$$T_2\ (x,\ s) = \sqrt{\frac{R}{Cs}}\ q\ (0,\ s)\ \epsilon^{-x\sqrt{RCs}} + \frac{T_0}{s} \qquad (7)$$

Equation 7 is an expression, in the transform domain, for the crystal temperature at any point x. Further, this equation is valid for any input waveform for which the Laplace transform exists.

REPETITIVE RECTANGULAR PULSED INPUT

IF THE INPUT WAVEFORM is a rectangular pulse of width a seconds, repeated every τ seconds, we may write $q\ (0, s)$ as

$$q\ (0,\ s) = \frac{\hat{P}}{4.186\ A}\ \sum_{n=0}^{\infty}\left\{\frac{\epsilon^{-n\tau s}}{s} - \frac{\epsilon^{-(n\tau+a)s}}{s}\right\} \qquad (8)$$

where

A = the area of the slabs (emitter area plus collector area) in square centimeters

4.186 = the conversion factor from watts to calories per second and

$\hat{P}$ = the peak input power in watts (emitter power plus collector power)

Equation 8 is valid over the normal range of temperatures where the power dissipation due to leakage cur-

*All accuracy statements in this article are referred to the electric analog.[3]

rent is negligible. At the higher temperatures (approaching thermal runaway conditions), this equation must be rewritten to account for the power due to leakage current.

For normal temperatures we may substitute the expression given in equation 8 for $q\ (0, s)$ into equation 7. This step results in

$$T_2(x, s) = \sqrt{\frac{R}{Cs}}\,\frac{\hat{P}}{4.186\,A}\,e^{-x\sqrt{RCs}}\sum_{n=0}^{\infty}\left\{\frac{e^{-n\tau s}}{s}-\frac{e^{-(n\tau+a)s}}{s}\right\}+\frac{T_0}{s} \quad (9)$$

By taking the inverse Laplace transform of equation 9 we obtain

$$T_2(x, t) = \sqrt{\frac{R}{C}}\,\frac{\hat{P}}{4.186\,A}\left[\sum_{n=0}^{\infty}\left\{2\sqrt{\frac{t-n\tau}{\pi}}\,\epsilon^{-RCx^2/4(t-n\tau)}-\right.\right.$$

$$\left.x\sqrt{RC}\,ERFC\,(x\sqrt{RC}/2\sqrt{t-n\tau})\right\}u(t-n\tau)-$$

$$\sum_{n=0}^{\infty}\left\{2\sqrt{\frac{t-(n\tau+a)}{\pi}}\,\epsilon^{-RCx^2/4[t-(n\tau+a)]}-\right.$$

$$\left.\left.x\sqrt{RC}\,ERFC\left(\frac{x\sqrt{RC}}{2\sqrt{t-(n\tau+a)}}\right)\right\}u[t-(n\tau+a)]\right]+T_0 \quad (10)$$

where $ERFC$ is the complementary error function defined as

$$ERFC\,(y) = 1-\frac{2}{\pi}\int_{\iota}^{\gamma}\epsilon^{-\gamma^2}\,d\gamma$$

For our case

$$y = \frac{x\sqrt{RC}}{2\sqrt{t-(n\tau-a)}}$$

Now, since $T_J = T_2\ (0, t)$, we obtain an expression for the junction temperature by allowing x to go to zero in equation 10. This step yields

$$T_J = \sqrt{\frac{R}{C}}\,\frac{2\hat{P}}{4.186\,A}\sum_{n=0}^{\infty}\left[\sqrt{\frac{t-n\tau}{\pi}}\,[u(t-n\tau)]-\right.$$

$$\left.\sqrt{\frac{t-(n\tau+a)}{\pi}}\,\{u[t-(n\tau+a)]\}\right]+T_0 \quad (11)$$

Equation 11 may be used to find the junction temperature for any time, provided the width of the input pulse remains less than 0.02 second. The maximum instantaneous junction temperature could also be taken from this equation. However, it would be necessary to solve for the steady-state conditions—a slow and laborious process. We will resort to an approximation to avoid these computations.

THE MAXIMUM JUNCTION TEMPERATURE

As a first step in obtaining an approximation for the maximum junction temperature with a rectangular pulsed input, we define a new term, $\Delta T_{J\max}$, for the steady-state condition. $\Delta T_{J\max}$ is defined as the difference between the junction temperature at the end of the power pulse and the junction temperature at the beginning of the following power pulse (see Fig. 3). If we are to avoid the problem of computing the steady-state values of T_J, we must approximate $\Delta T_{J\max}$. A good approximation is given by

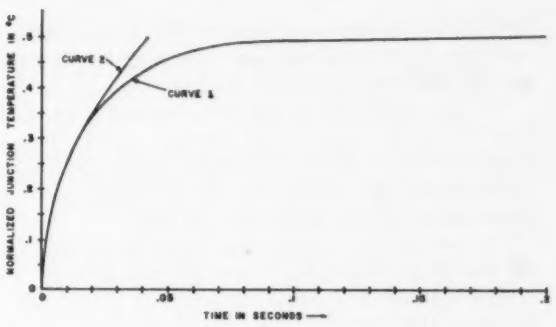


Fig. 2. Theoretical and analog unit step responses.

$$\Delta T_{J\max} \approx \sqrt{\frac{R}{c\,\pi}}\,\frac{\hat{P}}{4.186\,A}\left(2\sqrt{a}-\sqrt{\tau}+\sqrt{\tau-a}\right) \quad (12)$$

The next step in obtaining the maximum temperature is a study of the relations between the temperatures shown in Fig. 3. This figure shows T_J for a time sufficiently large to reach steady-state conditions. The temperatures shown are defined as:

$\overline{T}$ = the average junction temperature

$T_{\max}$ = the maximum junction temperature

T_0 = the ambient junction temperature

$T_{\min}$ = the minimum junction temperature

The average junction temperature may be obtained from

$$\overline{T} = T_0+\overline{P}\,\theta = T_0+\hat{P}\,\frac{a}{\tau}\,\theta \quad (13)$$

where

$\overline{P}$ = total average input power in watts

θ = thermal resistance from collector-base junction to mounting base in degrees C per watt

Also, by definition,

$$T_{\min} = \overline{T}-T_1 \quad (14)$$

Substituting the expression for T from equation 13 into equation 14, we obtain

$$T_{\min} = T_0+\hat{P}\,\frac{a}{\tau}\,\theta-T_1 \quad (15)$$

Returning to Fig. 3, we observe that

$$T_{max} = T_{min} + \Delta T_{J\,max} \tag{16}$$

Therefore, from equations 15 and 16,

$$T_{max} = T_0 + \hat{P}\frac{a}{\tau}\theta + \Delta T_{J\,max} - T_1 \tag{17}$$

Now, if we use the approximation for ΔT_{Jmax} given by equation 12, we need only an expression for T_1 to obtain the maximum junction temperature.

We may obtain an approximate expression for T_1 by determining the approximate average value of the temperature for the first cycle of operation, adding a correction factor, and using this corrected value as an approximation for the steady-state average.

We first assume a zero initial temperature and plot the first cycle of operation as given by equation 11. The first cycle of operation may be expressed as follows:

$$T_1(t) = \sqrt{\frac{R}{c\,\pi}}\frac{2\hat{P}}{4.186\,A}\sqrt{t} \qquad \text{for } 0 \le t \le a \tag{18}$$

$$T_2(t) = \sqrt{\frac{R}{c\,\pi}}\frac{2\hat{P}}{4.186\,A}\left[\sqrt{t} - \sqrt{t-a}\right] \quad \text{for } a \le t \le \tau \tag{19}$$

These expressions are shown in Fig. 4.

The approximate average value of the curve shown in Fig. 4 is given by

$$T_1 \approx \frac{1}{\tau}\int_0^a T_1(t)\,dt + \frac{1}{\tau}\int_a^\tau T_2(t)\,dt \tag{20}$$

The error involved in equation 20 results from the fact that T_J does not return to its initial value at the end of the cycle. We may partially correct for this error by subtracting one half of the area under the line $T_J = T_J(\tau)$ in Fig. 4. Adding this correction factor and performing the integration indicated in equation 20 yields

$$T_1 \approx \sqrt{\frac{R}{c\,\pi}}\frac{2\hat{P}}{4.186\,A}\left\{\frac{2}{3}\left[\sqrt{\tau} - \frac{(\tau-a)^{\frac{3}{2}}}{\tau}\right] - \frac{1}{2}\left[\sqrt{\tau} - \sqrt{\tau-a}\right]\right\} \tag{21}$$

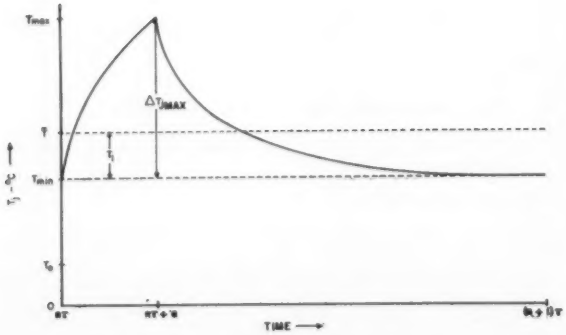


Fig. 3. Steady-state junction temperature.

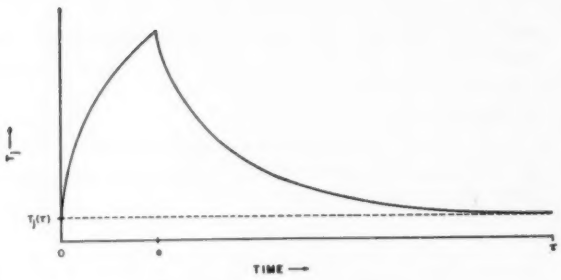


Fig. 4. First cycle of operation.

Equation 21 is an approximate expression for the average junction temperature during steady-state conditions when the initial temperature is zero. This average corresponds to T_1 in Fig. 3, regardless of the initial temperature, since it is the rise of the average temperature above the minimum temperature.

Now, substituting T_1 as given by equation 21 into equation 17, we obtain the approximate expression for the maximum instantaneous junction temperature for a rectangular pulsed input. This expression is given by

$$T_{max} = T_0 + \hat{P}\frac{a}{\tau}\theta + \sqrt{\frac{R}{c\,\pi}}\frac{2P}{4.186\,A}\left[\sqrt{a} - \frac{2\sqrt{\tau}}{3} + \frac{2(\tau-a)^{\frac{3}{2}}}{3\tau}\right] \tag{22}$$

Equation 22 is accurate to within 10% for pulses less than 0.02 second in duration. Also, the error is in a direction such that the actual junction temperature is always less than that given by equation 22. Therefore, for normal temperature ranges, we may employ equation 22 with confidence since there is an automatic safety factor in the equation.

EXPERIMENTAL JUNCTION TEMPERATURES

In the experimental determination of transient junction temperatures the collector reverse-leakage current, I_{CO}, was used as the external indicator of junction temperature. A calibration curve relating I_{CO} and T_J was obtained by placing the transistor in a temperature-controlled oven, applying the operating collector to base voltage V_{CB}, and measuring I_{CO} for various temperatures with the emitter lead open-circuited. The transistor must be allowed to reach the oven temperature throughout before a measurement of I_{CO} is made.

Using I_{CO} as the indicator of junction temperature puts some rather stringent requirements on the pulse test circuit. In order to use our calibration curve we must have the same V_{CB} as we used for calibration and the emitter must appear open-circuited when we measure I_{CO}. Further, our emitter circuit must have a low impedance during pulse "on" time. We are, therefore, restricted to pulse "off" (no pulse in) time for our measurements of junction temperature.

In Fig. 5, T_1, T_2, their associated coupling and power supply circuits, and D_1 are used to open and close the emitter circuit during "off" and "on" time. During "off" time T_1 is conducting and a positive voltage is coupled to the base of T_2. This positive voltage prevents conduction in T_2, thus placing a very high impedance in the emitter lead of T_3 and holding T_3 at cut-off. D_1 further assures no current flow in the emitter circuit of T_3 when there is no input signal.

During "on" time a positive pulse appears on the base of T_1, cutting T_1 off and thus removing the positive voltage from the base of T_2. Then T_2 will conduct heavily, due to B_1, and present a very low impedance to forward current in T_3. Since D_1 also presents a very low impedance to forward current flow in T_3, then T_3 will conduct during a positive input pulse. The amount of current in T_3 during "on" time is controlled by R_7. The amount of current in T_2 is controlled by R_8 during "on" time and is usually adjusted for saturation of T_2.

Collector reverse-leakage current is measured across R_6 with a cathode-ray oscilloscope during "off" time. A bypass diode, D_2, prevents overdriving of the oscilloscope by the heavy forward current.

The peak input power to T_3 during "on" time is given by

$$\hat{P} = I_E V_{EB} + I_C V_{CB} \qquad (23)$$

where

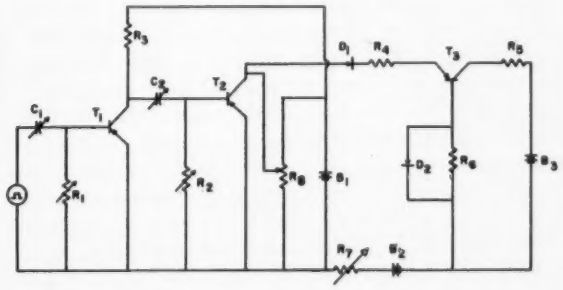
I_E = the emitter current in amperes

I_C = the collector current in amperes

V_{EB} = the emitter to base voltage in volts. Emitter and collector currents are monitored across R_4 and R_5 with an oscilloscope.

RESULTS

A DIRECT COMPARISON between theoretical and experimental results would necessitate calculating the steady-state conditions for the theoretical solution. We may avoid some of these calculations by comparing experimental and theoretical values of ΔT_J. We define ΔT_J as the difference between the temperature at any time during the cooling cycle and the minimum temperature (the temperature at the end of the cooling cycle).



R_1 = 0–10 kilohms
R_2 = 0–10 kilohms
R_3 = 200 ohms
$R_4 = R_5$ = 1 ohm
R_6 = 1 kilohm
R_7 = 0–1 kilohm
R_8 = 0–50 kilohms
$C_1 = C_2$ = 0–40 microfarads
$B_1 = B_2$ = 24 volts
B_3 = 60 volts
$D_1 = D_2$ = 0.5 ampere d-c, 5 amperes peak
$T_1 = T_2$ = type *H6* transistor
T_3 = test transistor

Fig. 5. Experimental circuit for measuring junction temperatures.

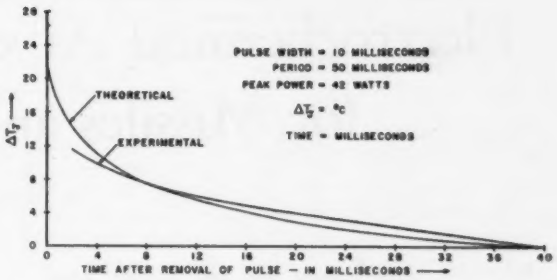


Fig. 6. ΔT_J vs time for cooling portion of the cycle for type *H6* transistor.

An exact determination of ΔT_J for the theoretical solution would, of course, require steady-state conditions. Using equation 11, we may approximate ΔT_J with the first few cycles of operation. The wave shape changes very little after a few cycles of operation. The number of cycles required for any given accuracy may be determined by comparing $\Delta T_{J\max}$ for successive cycles. When the values of $\Delta T_{J\max}$ for successive cycles are the same to the required number of places, the last cycle used is essentially steady state for ΔT_J.

Fig. 6 shows theoretical and experimental values of ΔT_J for the Minneapolis-Honeywell Regulator Company *H6* transistor. The experimental curve is an average for several transistors.

The curves in Fig. 6 compare favorably over most of the cycle. However, no reliable experimental data is available for the period immediately following the pulse. Electrical and thermal effects have not, as yet, been separated for this portion of the cycle. It is expected that once experimental data is available, the favorable comparison will extend throughout the cycle.

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Electrochemical Auxiliary Power Sources for Missiles and Space Flight

M. EISENBERG

Relatively high energy per unit weight, high power density, and high reliability are among the basic advantages of electrochemical power sources, which are being developed for missile and space flight applications. These sources, particularly electrochemical fuel cells, are described and compared with other energy-conversion devices.

ELECTROCHEMICAL BATTERIES, both primary and secondary, have assumed an important role in missile applications from the initial stages of missile development. With the advent of the space exploration age, fuel cell developments have been brought into the picture and although no satellites have yet been flown with fuel cells aboard, a great deal of development and engineering design is now in progress in this area.

The importance of electrochemical energy sources for missiles and space flight can be traced to some of the basic advantages of electrochemical systems. These advantages include

1. Direct conversion of chemical energy into electric energy
2. Convenience in scaling power systems up or down
3. Fewer maintenance and reliability problems, because there are no moving parts
4. Ease of tapping and transmission of power for a variety of different loads
5. Relatively high energy per unit weight in the case of fuel cells
6. A high specific power output (power density), particularly in the range of small size devices (Table I)

The data shown in Table I compare two electrochemical cells and a lead acid battery to other devices, including semiconductors, with respect to power density per unit volume and energy conversion efficiency. The high power density and energy conversion efficiency of a hydrogen–oxygen cell of the Bacon type (high pressure) is an outstanding feature and is responsible for the strong interest that has been shown in fuel cell development on the part of satellite designers.

ELECTROCHEMICAL ENERGY SOURCES

ONE OF THE PRIMARY CONSIDERATIONS involved in the selection of auxiliary power units for missiles and satellites is the energy-per-unit-weight ratio. Fig. 1 makes this comparison for a variety of electrochemical systems ranging from the conventional lead acid battery to fuel cells. For systems now commercially available, an estimate of further capacities through additional research and development efforts is shown by the broken lines. In regard to theoretical values, it should be pointed out that these figures refer to the active materials only and exclude the weight of the structural components, electrolyte, and case. Fig. 1 includes primary batteries, secondary batteries, and fuel cells. In addition to the energy-per-unit-weight ratio, there are other important considerations such as energy-per-unit-volume ratio, shelf life, activation time, behavior under extremes of temperature, shock, vibration, and other environmental conditions.

In missile applications, primary high-discharge-rate batteries are today almost exclusively employed. For satellite applications, on the other hand, fuel cells are currently being developed. It is, therefore, convenient to discuss these devices separately.

Table I. Specific Power Output and Energy Efficiency of Several Conversion Devices

System	Specific Power Output, watts per cubic foot	Corresponding Maximum Energy Efficiency, 2 per cent
High-Pressure H_2/O_2 Cell	2,000	70
High-Temperature Co/Co_2 Cell	350	60
Lead Acid Cell	280	85
Diesel Alternator	140	38
Boiler Turboalternator	1,000	40
Semiconductor Solar Battery	140	6
Thermoelectric Battery	16	7

Primary Batteries. The preference for primary batteries over secondary storage batteries in missile application is dictated by the fact that there is a short one-time use involved, except, of course, for ground check-out procedures. The average battery life in a missile is anywhere from 4 to 7 minutes. This short life requires development of special types of batteries capable of high drainage. These batteries are commonly referred to as "high rate" cells. Another fundamental consideration is the requirement of a high energy-per-unit-weight ratio. It is well known that the saving of 1 pound in the weight of a battery results in a saving of 60 to 100 pounds of fuel. There are few fields in which the incentive for research and development in this direction is as impressive. It is for this reason that the advent of the missile requirements has given rise to a renewed surge of interest in the direction of newer and better battery systems.

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Missile batteries are different in many ways, because their design must meet unique requirements. These designs employ very active electrochemical systems, thin plates, thin separators, and other features which emphasize large electrode areas and reduced internal battery resistance. The missile batteries must be lightweight and be capable of operation under unusually stringent environmental conditions of temperature, shock, vibration, and low pressure.

A great deal of development has gone into the silver-zinc system which is now generally available in the 30 to 40 watt-hours-per-pound ratio. If necessary, this ratio can be stretched to about 80 watt-hours per pound.

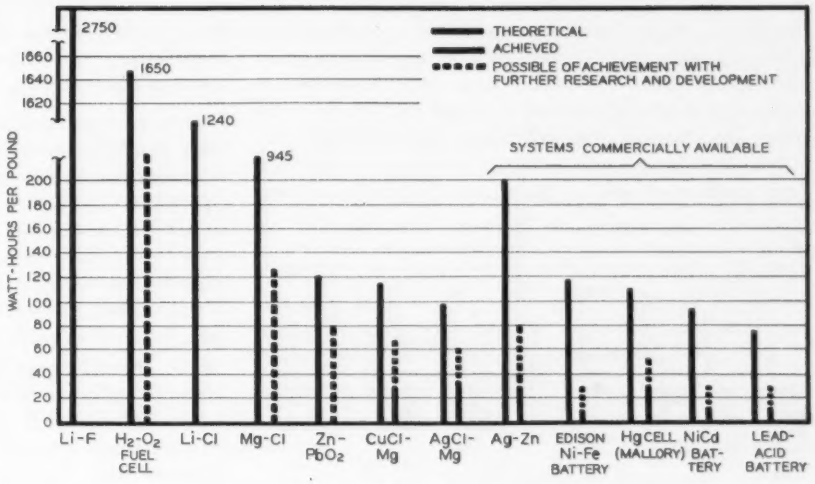


Fig. 1. Comparison of various electrochemical energy sources.

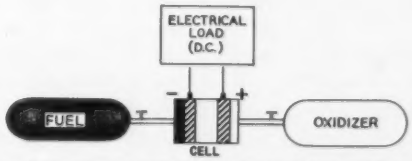
One of the most important problems, however, in missile applications is the limited shelf life of the silver–zinc cells under activated stand. To overcome this problem, remote activation mechanisms are universally used to activate a battery just a few seconds prior to firing of the missile. This involves three serious disadvantages:

1. The battery cannot be checked out prior to its use. This represents a serious handicap from a reliability point of view and can result in loss of costly missiles and disastrous firings.
2. The mechanism itself may fail, thus representing an added reliability problem.
3. The weight of the mechanism may amount to as much as 30% of the total auxiliary power unit package, thus increasing the need for more fuel in a given missile task.

The foregoing considerations indicate clearly that the missile industry will have to take initiative on its own in the research and development area of primary batteries. An obvious research goal is to develop a battery which will have a good shelf life, with the electrolyte filled into the cells for periods of at least 3 to 6 months. Such a period is probably a minimum practical operational period which regular maintenance could handle.

A careful consideration of other auxiliary power unit systems for missiles leads to the conclusion that no other devices, including fuel cells, appear practical because of the short durations involved. There have been some misconceptions as to the applicability of fuel cells to missiles. It should be recognized that the large watt-hours-per-pound ratio in fuel cells is realized only when they are used for relatively long periods of time. These periods should be at least 20 to 30 hours, and preferably much longer. Mechanical devices have long been ruled out from the point of view of weight, reliability, and several other considerations. Thus, the missile field appears to have a continuing long-range stake in the development of new and better primary battery systems.

Fuel Cells. Electrochemical fuel cells have achieved a new stature of importance with the advent of satellite and space flight applications. As is well known, the concept is relatively old, going back to Sir Humphrey Davy in 1802. A critical historical survey of research and development in this field indicates that the thermodynamic consequences of the fuel cell have been fairly well understood. Since World War II there has been impressive progress in the field of fuel cells. Fig. 2 shows schematically a fuel cell in which the "fuel" simply refers to the anodic reactant and the oxidizer refers to the cathodic reactant. It is possible, of course, to look at fuel cells from two points of view; one is to compare them to other engines or other energy devices and the other is to compare them to existing types of electrochemical batteries. This has been done in Fig. 2, in the left and the right tables, respectively. As will be



DIRECT CONVERSION OF CHEMICAL ENERGY TO ELECTRICAL (WITHOUT AN INTERMEDIATE HEAT STEP)

ENERGY CONVERSION EFFICIENCIES	
FUEL CELLS	50 - 70%
GASOLINE ENGINE	15 - 24%
DIESEL ENGINE	27 - 38%
LARGE STEAM TURBINES	25 - 29%
THERMOELECTRIC DEVICES	6 - 14%

ENERGY PER UNIT WEIGHT RATIOS (WATTHOURS/LB.)	
FUEL CELLS	100 - 350
LEAD-ACID BATTERIES	8 - 14
NICKEL CADMIUM BATTERIES	7 - 10
MERCURY - ZINC BATTERIES	20 - 35
SILVER - ZINC BATTERIES	30 - 60

Fig. 2. Schematic diagram of electrochemical fuel cell.

discussed later, fuel cells are not limited by Carnot cycle efficiency and are, therefore, capable of achieving very high efficiencies. On the other hand, in a comparison of energy-per-unit-weight ratios, fuel cells are 10 to 35 times better than lead–acid or nickel–cadmium batteries.

Initially, the motivation for fuel cell research has been from the point of view of utilization of carbonaceous fuels.

Table II. Characteristics of Several Types of Hydrogen-Oxygen Fuel Cells

Type of Cell	Temperature, degrees C	Pressure, atmospheres	Open Cell Voltage	Current Density at $V_c = 0.75$, amperes per square foot	Power Density* (cell alone), watts per cubic foot
Bacon	240	52	1.05	440	2,400
Justi	50	2.6	1.07	250	1,360
Carbon electrodes (with air)	60	1	0.95	14	77
Carbon electrodes (oxygen)	60	1	0.98	20	110
(oxygen)	60	5	1.02	35	192

* Calculated at $V_c = 0.75$ volt for the plate and frame type construction o 1-inch-thick cells with a 28% volume allowance for cell housing.

This has been extended to hydrogen–oxygen fuel cells. The latter system has, in recent years, attracted considerable attention from people who are concerned with space flight application. It may, therefore, be interesting to compare several relatively successful hydrogen–oxygen fuel cells shown in Table II. The last two columns show the current density at a cell voltage of 0.75 volt and the power density. The Bacon cell employs porous nickel electrodes and the Justi cell a porous nickel anode. All the other cells shown in Table II employ carbon electrodes. It is obvious that both the current density and the power density are, by at least an order of magnitude, larger for the Bacon and Justi cells.

The hydrogen–oxygen fuel cell has some serious disadvantages, however, especially for space flight applications. Among these are:

1. The hydrogen–electrode is susceptible to "poisons." Minute traces of these poisons are preferentially absorbed on the electrode-active sites and greatly increase the polarization losses.

2. Inside a satellite or space ship in which zero gravity prevails, fuel cells operating on gases are subject to a considerable technical difficulty because any gas bubbles which would appear on the electrolyte side of the plates could not rise. Changes in the load on the fuel cell would result in the probability of such gas bubbles accumulating on the faces of the electrodes inside the cell. This would lead to serious losses of voltage regulation, power, and could eventually result in a blocking of the total current.

3. Storage of hydrogen represents a rather serious problem. In order to keep hydrogen in a liquid form it must be maintained at −240 C at 12.8 atmospheres (triple point). The alternative (storing hydrogen as a cold gas) leads to a requirement of tanks of a weight ratio 8 to 20 times that of the weight of the hydrogen itself.

4. In a hydrogen–oxygen fuel cell with alternating compartments into which hydrogen and oxygen gases are fed, any leak which may develop could result in a formation of dangerous explosive gas mixtures and, therefore, a serious hazard exists.

To overcome some of these difficulties, a new cell has been developed in the Electrochemical Laboratory at Lockheed Missile Systems Division, based on the use of a liquid fuel. The theoretical watt-hours per pound of this system are superior to that of the hydrogen–oxygen system if one takes into account the fact that in the vicinity of room temperature the oxygen corresponds to $O_2 + H_2O + 2O^- = HO_2^- + OH^-$. The theoretical maximum cell voltage $E^\circ = -0.0416$ volt.

This peroxide stage results in a loss of almost 0.4 volt as compared to the reaction at high temperature.

The Lockheed cell operates at room temperature and very moderate pressures. The total system, including all necessary hardware, fuels, and storage, gives an energy-per-unit-weight ratio of 200 to 350 watt-hours per pound. A typical example is a ratio of 310 watt-hours per pound for a 250-watt system operating for 100 days. It should be emphasized that the longer the duration of the application, the greater is the energy-per-unit-weight ratio, and the greater the incentives for application of fuel cells. Fuel cells should not be considered for applications for 10 hours duration and they should be, preferably, over 100 hours. As will be discussed toward the end of this article, fuel cells should be considered as highly efficient engines and ultimately should be combined with nuclear or solar energy to yield devices for maximum utilization of these prime sources of energy.

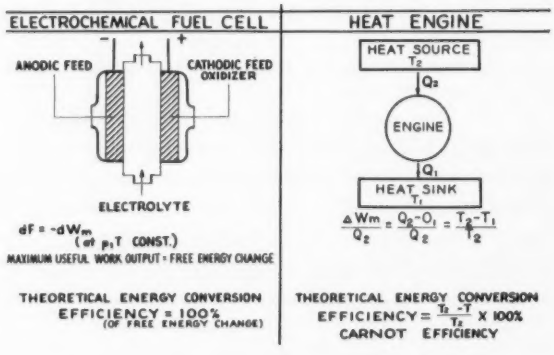


Fig. 3. Comparison of fuel cell and heat engine.

Secondary Batteries. Secondary batteries, commonly referred to as storage batteries, may have some useful, although limited, applications for spacecraft. A typical application of this is the use of a storage battery in conjunction with solar cells mounted outside of the satellite. At an energy conversion efficiency (based on incident solar energy) of 6 to 10%, solar cells are capable of 8 watts per square foot of collector area when fully exposed to sunlight. This energy can be used to charge a storage battery that, in turn, would power the necessary electronic equipment aboard the vehicle. Otherwise, only intermittent operation

of the communications link with the vehicle would be possible. It is estimated that for a 200-watt installation about 100 square feet of solar cells would be required (i.e. a 24-hour average of 2 watts per square foot of output) and such an installation together with a storage battery would have an effective weight of 1.6 pounds per watt. From the point of view of the choice of the storage battery, the nickel–cadmium system is particularly desirable because high reliability can be achieved by continuous float-charging. Other advantages of the nickel–cadmium system are: good performance over a wide range of temperatures from −60 to +160 F and very good shelf life in the wet discharged state. On the other hand, silver–zinc storage batteries are capable of only about 20 charge–discharge cycles as compared to a service life of 300 to 2,000 cycles for the nickel–cadmium battery.

FUNDAMENTAL PRINCIPLES OF ELECTROCHEMICAL FUEL CELLS

In view of the particular importance of fuel cells for space flight, it may be useful to discuss briefly some of the principles of operation of electrochemical fuel cells. The fundamental importance of the fuel cell becomes apparent if one discusses an electrochemical fuel cell in comparison to a heat engine, whether it be a mechanical engine, a thermoelectric device, or a thermionic device.

The conversion of useful energy from one form to another is generally limited when heat occurs as an intermediate form of energy.* The theoretical efficiency of any cycle in which heat energy occurs as an intermediate form is that of a Carnot cycle. This efficiency, $(T_2 - T_1)/T_2 \times 100\%$, depends simply on the temperature of the heat source T_2 and of the heat sink T_1 and, therefore, is limited, not only by the nature of the cycle fluid, but also by the materials of construction.

The Carnot efficiency corresponds to that of the most efficient heat engine (or other devices based on heat, such as thermoelectric and thermionic) operating close to thermodynamic reversibility, i.e., infinitely slow. In reality, there are many heat losses and other losses, so that in present-day power plants the efficiency of conversion of the chemical energy of fuels to electric energy ranges from 20 to 40%. This waste of the available chemical energy of fuel has been fully recognized for many years and has given rise to repeated efforts and speculations on the possibility of converting the energy of the fuels directly to electric energy in electrochemical devices. This has been achieved successfully in primary and secondary devices, and most recently in continuous systems: the so-called electrochemical fuel cells.

These devices are not subject to Carnot efficiency and, therefore, the theoretical limit is 100% of the free energy change. This has been well known for a long time, and much of the free energy data has been obtained by setting up special galvanic cells and operating them very slowly so as not to depart from the equilibrium.

It can be shown readily from thermodynamic considerations that in an electrochemical process operating at constant temperature and pressure, the change of free energy is

$$dF = -dW_m \tag{1}$$

Hence the change is equal to the maximum useful work obtainable from a galvanic reaction. Fig. 3 shows a comparison of the heat engine and the electrochemical fuel cell.

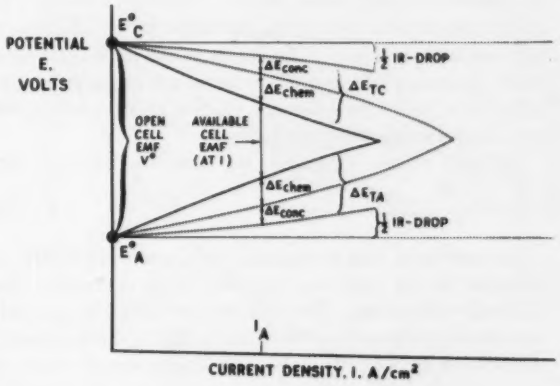


Fig. 4. Potential–current relationships in a fuel cell.

The free energy change for an isothermal and reversible cell is related to the emf (electromotive force) by the simple relation

$$\Delta F = -n\mathcal{J}E^\circ \tag{2}$$

where

ΔF = free energy change in joules per mole
$\mathcal{J}$ = number of coulombs per equivalent = 96,500 (the Faraday)
n = number of electrons per reacting ion or molecule
E° = theoretical maximum cell voltage for the over-all chemical reaction

The open cell voltage (i.e., when no current is flowing) is the highest obtainable experimentally. For a reversible cell, the open cell voltage is equal to the theoretical maximum voltage resulting from equation 2.

The well-known Gibbs-Helmholtz equation, when combined with equation 2, has the form

$$\Delta H = -n\mathcal{J}\left[E^\circ - T\frac{\partial E}{\partial T}\right]_p \tag{3}$$

Hence, the last change of the reaction occurring in the cell can be conveniently calculated from the emf, E°, and its temperature coefficient.

When the process occurs irreversibly at a constant temperature and pressure, then the useful work, i.e., the electric energy obtained, is always less than the decrease in the free energy of the system. For an actual working cell, the heat of reaction is then given by

$$Q_{cell} = n\mathcal{J}(E^\circ - E_{cell}) + T\Delta S \tag{4}$$

where E° is the reversible emf of the cell and E_{cell} is the actual emf of the cell at the current density at which it

*It is important to differentiate this from heat generated incidentally in a process as a result of irreversibility.

operates. In practice, the enthropy term $T\Delta S$ is usually very small, so that the predominant heat of reaction results from thermodynamic irreversibility of the cell (polarization of each electrode and ohmic potential drops).

The thermodynamic aspects have been fairly well understood for a long time, although not always properly interpreted. What has, however, impeded the developments in the field of fuel cells is the lack of basic kinetic studies. It is in this area that a great deal of research and development is still badly needed. Consider a fuel cell at open circuit with individual electrode potentials shown schematically in Fig. 4. The values of the individual electrode potentials E°_C and E°_A refer to the standard potentials (vs. a hydrogen reference electrode) after correction for activities different from unity

At open circuit, therefore, we have an open cell emf

$$V^\circ = E^\circ_C - E^\circ_A \tag{5}$$

As soon as a load is applied, each electrode begins to polarize in the opposite direction, thus decreasing the available cell voltage. This can be seen in Fig. 4, in which the ohmic potential drop through the cell is shown equally distributed between cathode and anode for the sake of symmetrical presentation. Each electrode polarization

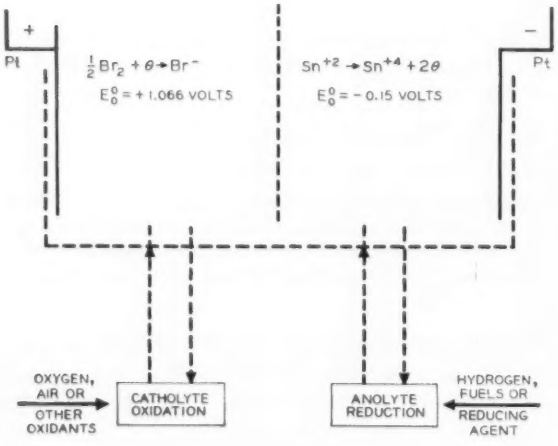


Fig. 5. Schematic diagram of redox fuel cell.

includes at least two components: the chemical polarization ΔE_{chem}, due to one or more slow activation steps in the electrode reaction, and the concentration polarization ΔE_{conc}, associated with the slowness of the ionic mass transport to and from the electrodes. Thus, the cell voltage V_c, at a load current i can be expressed as

$$V_c = (E^\circ_C - \Delta E_{conc.\,C} - \Delta E_{chem.\,C}) - (E^\circ_A + \Delta E_{conc.\,A} + \Delta E_{chem.\,A}) - \Sigma\, i\, R_i \tag{6}$$

The chemical polarization is related to the nature of the electrode reaction itself and to the catalytic effects of the electrode surface.

The solid-stage properties of the electrode material or of the catalysts employed on the electrode have a definite effect on the magnitude of chemical polarization losses. Closely related to this problem is the effect of the so-called "electrode poisons." These are substances which are preferentially chemisorbed on the electrode surface and which change the mechanism of the electrode reaction in a manner which increases the activation energy barriers, thus increasing the losses caused by chemical polarization.

Concentration polarization ΔE_{conc} is, on the other hand, related to processes outside the electrode itself, namely to the rate of migration, diffusion, and convection, which together determine the over-all rate of ionic mass transport. An increased mode of convection will increase the limiting current density I_L, and thereby decrease losses from concentration polarization, since the latter are related by the expression

$$\Delta E_{conc} = \frac{RT}{nF} \ln\left(\frac{I_L}{I_L - I}\right) \tag{7}$$

where

I_L = limiting current density
I = applied current density

In electrochemical fuel cells, concentration polarization can be very significant, and it is easy to demonstrate that high rates of mass transfer are important. Thus, for large electrochemical fuel cell systems it appears that continuous circulation is essential.

Closely related to the problem of ionic mass transfer and convection is a problem which arises almost exclusively in space flight applications. It is the problem of weightlessness and its effect on the performance of batteries and fuel cells.

In all those galvanic systems in which concentration gradients of reactants or products can develop in the vicinity of the electrodes, the electrode reaction remains under the influence of a free convection flow. This flow is caused by a buoyancy force resulting from a density difference when the cell operates in a gravity field.

It has been shown that free convection [1,2] offers a sizable benefit which one normally obtains when using batteries with soluble anodes such as silver–zinc batteries on the ground. Depending on the geometry of the silver–zinc battery, it has been calculated that in the absence of free convection the limiting current density may be smaller by a factor of 5 to 20. This effect applies to batteries, does not apply to dry cells, and applies only to a minor extent to those galvanic systems in which anode products and cathodic reactants are insoluble.

In the case of fuel cells, concentration gradients always develop near the electrodes and in a gravity-free field one would lose the benefit of natural convection and would have to depend on forced convection. This is perhaps not as serious as another consideration which may arise primarily in fuel cells employing hydrogen, oxygen, or other gas electrodes. Since the supply of the gas to the back side of the electrode is normally preset at a constant level, even a moderate reduction of the electric load on the cell would result in a reduction in the rate of the electrochemical consumption of the gas, and gas bubbles

would form on the electrolyte side of the porous electrodes. In a gravity-free field, such bubbles cannot be expected to separate from the electrolyte, even when strong forced convection is employed to sweep them away from the electrode surfaces. The circulating electrolyte would soon become loaded with an increasing number of gas bubbles. Considerations of this type are necessary both in the choice of the type of electrodes and in the design of fuel cell systems.

In recent years, an increasing measure of attention has been given to redox cells, i.e., cells employing two different redox couples which, upon regeneration, are returned to the cell compartments to react once more. A schematic of such a cell proposed in England[3] is shown in Fig. 5. The principal advantage of redox cells is that the chemical polarization of the bromine electrode is very small. The polarization of the stannous–stannic electrode is not exhorbitant either. However, the ohmic potential drop is sizable in the system, a matter that probably may be corrected by better choice of electrolytes and better design of the geometry of the cells. Fig. 6 is shown here, not just to discuss the particular system, but also to demonstrate what kind of data and what mode of presentation are desirable for an objective evaluation of any electrochemical system proposed for fuel cells.

CONCLUSION

ALTHOUGH the present emphasis is on the development of auxiliary power units for spacecraft, there are numerous applications of a military, commercial, or industrial nature for which fuel cells appear to be not only suitable but desirable. Some of these are as follows:

Military and Space Applications

Satellites and space vehicles (auxiliary power source)
Remote radar and microwave stations (auxiliary power source)
Ground support equipment (propulsion)
Submarine propulsion
Short-range transport planes and helicopters
Truck and car propulsion

Commercial and Industrial Applications

Television and microwave repeater stations
Fork lifts and other materials handling equipment
Auxiliary power supplies
Emergency stand-by power supplies
D-c power from natural gas pipeline for microwave stations
Domestic d-c power from natural gas in remote areas
D-c transmission
Automotive transportation ("Elecar")
Power source for cathodic protection of pipelines

Naturally, each application has its own peculiar requirements and could be discussed at great lengths. However, what is important to emphasize is that even in military applications some fuel cell systems which may be reasonable from an economic point of view to employ aboard satellites may not be acceptable for ground support equipment. Of course, all commercial applications are tied to economics and convenience.

Since an electrochemical fuel cell may be considered as the most efficient engine known to man, future trends in the development of these cells may be in the direction of combining them with nuclear energy sources. In practice, this would mean that for a given size of an isotopic source or a reactor, twice the energy may be obtained by using fuel cells instead of heat engines. The paramount importance of this simple fact to space flight applications is fairly obvious. There are two ways in which nuclear energy might be used in conjunction with fuel cells: in one case it is the heat output, and in the other case the radiation energy, which are used to split the product of the over-all fuel cell reaction back into the original

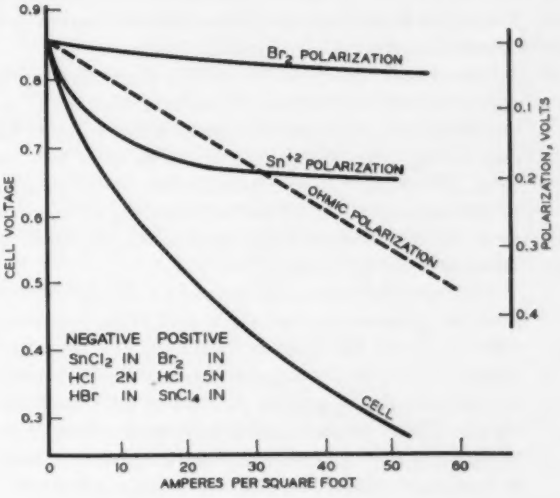


Fig. 6. Operating characteristics of stannous ion–bromine cell.

cathodic and anodic reactants. In the event that heat is employed together with a fuel cell, the cell still remains an electrochemical device, but the entire system together with regeneration represents a Carnot cycle in which the regeneration temperature corresponds to a source temperature and the operating temperature of the fuel cell corresponds to a heat-sink temperature. Thanks to the high energy-conversion efficiency inside the cell alone, however, total energy efficiencies as high as 48% can be obtained for the entire system, as compared to about 25% for a reactor–heat engine combination. There are problems in compatibility, special design requirements relating to the nuclear energy sources, and other fundamental problems, as well as engineering problems. The incentives, however, for efforts in this direction are fairly obvious and almost mandatory.

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Communication Systems for Railway Traffic Control

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CONTROL of railway traffic from a central location requires the transfer of large amounts of information between the central location and many points along the railroad. The number of wayside information points depends on the type of signaling installed.

Centralized traffic control (CTC) requires reliable 2-way communication between a control office and a number of wayside locations. A typical installation of CTC may extend over 200 miles with 40 or more field locations. The plant at a field location may comprise a track switch and signals at the end of a passing siding or may be a fair-sized interlocking, previously controlled by a local operator in a tower.

The control system is the part of a CTC system which provides communication outbound from the control office to any of the wayside locations. The information input to this system is supplied by levers or push buttons operated by the dispatcher to control track switches or signals. These levers or push buttons are located on a control machine or console, placing an entire division of a railroad virtually at the dispatcher's fingertips.

The indication system provides communication inbound from the many field locations to the control office. The input is provided by contacts on signal relays at the field locations and the output is used to position relays at the control office. These relays generally control lamps on the dispatcher's panel to show the location of trains and the position of signals and switches.

CTC systems differ from conventional communication systems in that they are multistation rather than end-to-end systems. This fact means that every relay or tube added to a field unit is multiplied by 25 or more on any typical installation. It is, therefore, very desirable to keep these units as simple as possible. Furthermore, since there are so many wayside locations, the line apparatus must be designed to bridge rather than terminate the line and present as little bridging loss as possible.

Railroads having high traffic densities, for example, subways and commuter lines, often require the reporting of train movements over many short-track circuits or blocks. A communication system is required which is capable of transmitting many digits of information with only one or two digits originating at any one location. A simple tone system is one means of doing this job. Tone transmitters of different frequencies are situated at the various blocks and are keyed when these blocks are occupied. Tone receivers at the dispatcher's office operate relays to energize lamps on a miniature track diagram.

An extension of the tone system provides two independent digital indications on one tone channel. The pair of line wires over which the tone system operates carries a direct voltage which is pole-changed 75 times per minute. During the time that line voltage is of one polarity, each tone channel carries one indication. When the line voltage is switched to the opposite polarity, each tone channel carries a different indication. The tone transmitters and receivers are transistor-operated.

A unique feature of this system is the fact that local energy is not required for the transmitters at the field locations. Pole-changed line energy is fed to the transmitters through a diode switching network and contacts on the relays to be indicated. This arrangement is ideal for a system of this type which often derives inputs from contacts of track relays at locations where energy is not available.

Sometimes it is necessary to relay analog information such as water level or freight car journal temperatures (measured by trackside infrared detectors) from the field to the control office. An FM telemetering system is used. The analog data, in the form of voltages, vary the frequency of subcarriers by amounts proportional to the voltages. At the receiving location, the variable-frequency subcarriers are converted to voltages identical to the input signals. A single-side-band voice channel carrier system handles these subcarriers on the line.

The railway signaling art has developed in the past independently of wire communications and electronics. Certain standard practices have evolved as the result of years of rigorous field experience. Continuity of service and maintainability are important requisites of railroad signal equipment.

One important practice is the use of 3,000-volt insulation in line and power circuits. This insulation level permits the use of lighting arresters with sufficiently large gaps to make it unlikely that a discharge will result in a permanent short circuit. Transistor-operated apparatus requires voltage-limiting devices in addition to lighting arresters to protect them from voltage surges that are tolerated by conventional signal apparatus.

Electronic chassis used in signaling must allow the same external wiring practice as other devices such as relays. All external leads must be tolerant of exposure to voltage surges. The impedance of external circuits must be low and pulse widths and rise times must be great enough so that deterioration due to wiring capacitance is not serious. Adjustments are kept to an absolute minimum. All chassis are provided with plug connectors so that a defective unit may be replaced quickly.

Digest of paper 59-249, recommended by the AIEE Land Transportation Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 1-6, 1959. Published in AIEE *Applications and Industry*, Mar. 1959, pp. 30-35.

H. C. Sibley is with the General Railway Signal Company, Rochester, N. Y.

Safety in A-C Substation Grounding

AIEE COMMITTEE REPORT

Under fault conditions, the flow of current to earth will result in possibly hazardous voltage gradients in and around substations. An analytical approach to this subject, based on a study by AIEE Working Group 56.1, has been developed.

UNDER FAULT CONDITIONS, a substation ground grid may rise some thousands of volts above true earth potential. Moreover, and more serious from a safety standpoint, local gradients can sometimes be such that they might impose hundreds, or even thousands, of volts between the hands of a man touching a "grounded" object, and his feet; or between his two feet while walking (Fig. 1). These dangerous conditions can arise from the coincidence of several adverse factors related to current intensity, ground resistivity, ground grid size and arrangement, location and position of the victim, lack of resistance in series with the body, and shock duration. There may, in fact, be many who owe their lives more to the operation of the laws of probability than to careful design against ground gradient hazards; for while the computation and measurement of station ground resistance has received much study, the problem of gradients has been somewhat neglected.

The reasons are not hard to understand. First, accidents have not been frequent enough to underline the need. Second, it has been hard to find an analytical approach simple enough for practical use, yet valid for most actual situations. An attempt to develop such an approach was made by AIEE Working Group 56.1, as reported in 1958. This has since been extensively revised and extended, and approved by the AIEE Standards Committee for publication under the title "Guide to Safety in A-C Substation Grounding."

In the approach to the problem used by the Guide, it is first assumed that the tolerable shock current is that just below the threshold of ventricular fibrillation of the heart. According to Prof. C. F. Dalziel, this current I_k, in amperes, is given by the following equation:

$$I_k = \frac{0.165}{\sqrt{t}} \tag{1}$$

where

t is the shock duration in seconds

Fault-clearing time is of major importance to safety. In the first place, the probability that a man will be in the wrong place at the wrong time is much less with any reasonably fast type of fault clearing, as compared to a situation where faults can persist for minutes or hours. (Most fatal accidents have resulted under the latter circumstances.) In the second place, it is apparent from equation 1 that when a shock does occur, the chance of survival is much greater if the shock duration is brief, preferably a small fraction of a second.

With tolerable currents defined by equation 1, tolerable shock voltages can next be computed. These may be either "step voltages" (between the feet when walking, as in Fig. 2) or "touch voltages" (between an object touched by the hand and the ground beneath the feet, as in Fig. 3).

From Fig. 2:

$$E_{step} = (R_k + 2R_f)I_k \tag{2}$$

Tests have shown that R_f, the resistance of the ground under one foot is approximately $3\rho_s$ ohms, where ρ_s is the resistivity of the soil immediately beneath the feet in ohm-meters. If we assume a body resistance R_k of 1,000 ohms, the maximum tolerable step voltage becomes

$$E_{step} = [1{,}000 + 6\ \rho_s]\ \frac{(0.165)}{\sqrt{t}} = \frac{165 + \rho_s}{\sqrt{t}} \tag{3}$$

A tolerable value for touch voltage is derived in like manner, except that the resistances under the two feet are in parallel (see Fig. 3):

$$E_{touch} = \left[1{,}000 + \frac{3\ \rho_s}{2}\right]\frac{0.165}{\sqrt{t}} = \frac{165 + 0.25\ \rho_s}{\sqrt{t}} \tag{4}$$

The problem, then, is to design a station so that ground gradients, during fault conditions, cannot result in any step or touch voltages greater than the tolerable values as determined in the foregoing.

The typical basic substation ground system is a grid of horizontal conductors, buried from a few inches to a few feet below the ground surface. It can be shown that the maximum actual step and touch voltages, with such a grid, are approximately as follows:

$$E_{step} \approx K_s K_i \rho\ \frac{I}{L} \tag{5}$$

$$E_{touch} \approx K_m K_i \rho\ \frac{I}{L} \tag{6}$$

A special article recommended for publication by the AIEE Substations Committee.

The personnel of AIEE Working Group 56.1 on Voltage Gradients Through the Ground Under Fault Conditions are: R. F. Stevens, chairman; E. C. Rankin, Beverly Peet, J. G. Cassan, G. W. Swanson, R. V. Smith, C. F. Dalziel, E. T. B. Gross, R. X. French, and S. J. Schwarz.

where

ρ is average resistivity of ground in ohm-meters
I is maximum total rms current in amperes flowing between ground grid and earth. (Allowances may be made for decrement and for future system growth)
L is the total length of buried conductor in meters
K_m and K_s are coefficients which take into account the effect of the number n, spacing D, depth of burial h, and diameter d of the grid conductor
K_i is a coefficient which allows for nonuniformity of current flow from various parts of the grid

In the Guide, it is shown that

$$K_s = \frac{1}{\pi}\left(\frac{1}{2h} + \frac{1}{D+h} + \frac{1}{2D} + \frac{1}{3D} \ldots \text{etc.}\right) \quad (7)$$

where the number of terms within the parentheses is equal to n, the number of the parallel conductors in the basic grid, excluding cross connections. Similarly,

$$K_m = \frac{1}{2\pi} \ln \frac{D^2}{16hd} + \frac{1}{\pi} \ln \left(\frac{3}{4}\right)\left(\frac{5}{6}\right)\left(\frac{7}{8}\right) \ldots \text{etc.} \quad (8)$$

where the number of factors within the logarithm of the second terms is $n-2$.

It will be noted that n, D, h, and d appear in these equations in such a way that they can vary over a fairly wide range without great effect on K_s and K_m. For this reason some European writers have suggested, as rule of thumb values, $K_s = 0.1$ to 0.2 and $K_m = 1.0$. These may be of the right order for most situations. However, for the place where step potential is greatest, i.e., just outside the grid perimeter, K_s can be somewhat larger than this (perhaps several times as large), especially if n is very large. K_m, on the other hand, is nearly always less than unity.

As a typical example, for 8 grid conductors of 4/0 Awg spaced in parallel lines 8 meters apart and 0.5 meter deep, $K_s \approx 0.42$ and $K_m \approx 0.80$. For the same grid at 1 meter depth, $K_s \approx 0.26$ and $K_m \approx 0.71$.

K_i will vary with grid geometry from perhaps 1.15 for a very simple mesh to about 2.25 for a more finely divided or irregular grid. (Even larger factors would be needed to cover long narrow projections from the general grid perimeter; therefore, these should normally be avoided where gradients may be critical.)

E_{touch} as obtained from equation 6 is the voltage between the feet, when standing at the center of a grid mesh, and a hand in contact with a conducting object grounded to the grid. This special case for E_{touch} is sometimes called the "mesh voltage" or E_{mesh}.

In the preliminary design of the station grid, a conductor will usually be included which encircles the periphery, preferably just outside the fence line. Next, other grid conductors will usually be located in parallel lines along the rows of equipment for grounding the equipment frames, structures, neutrals, etc. These will normally be extended at each end to join the perimeter

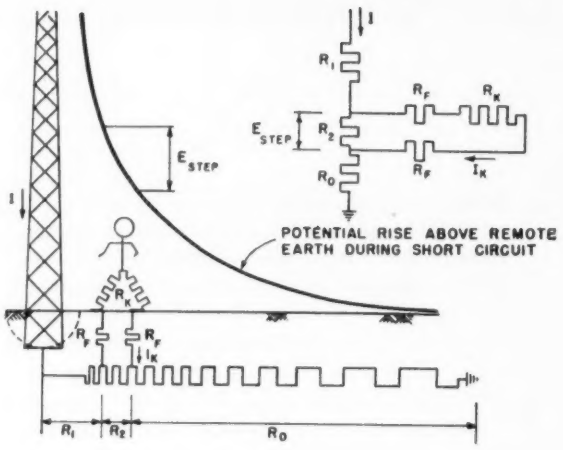

Fig. 2. Step potentials near grounded structure.

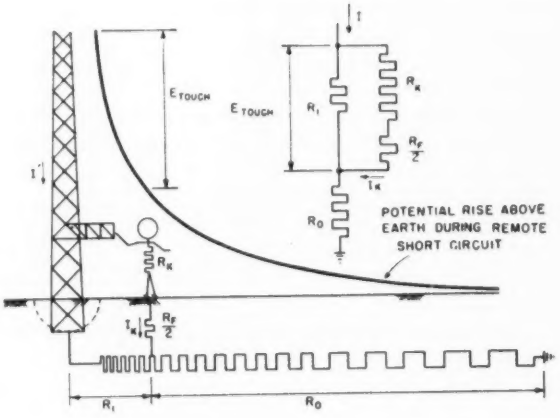

Fig. 3. Touch potentials near grounded structure.

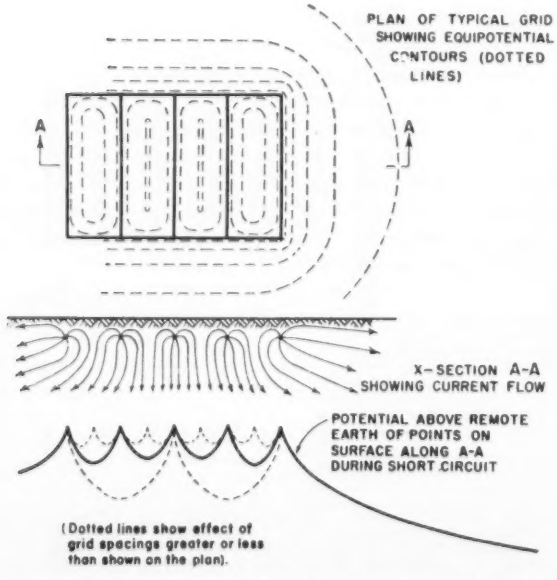
PLAN OF TYPICAL GRID SHOWING EQUIPOTENTIAL CONTOURS (DOTTED LINES)
A
A
X-SECTION A-A SHOWING CURRENT FLOW
POTENTIAL ABOVE REMOTE EARTH OF POINTS ON SURFACE ALONG A-A DURING SHORT CIRCUIT
(Dotted lines show effect of grid spacings greater or less than shown on the plan).

Fig. 1. Currents and potentials in and around ground mat area.

conductor. Some cross connections and ground rods will usually be added.

To determine whether the total length of buried conductor thus planned is sufficient for gradient control, equation 4 for tolerable touch potential is equated to equation 6 and the result solved for L. This gives the minimum conductor length needed, in meters, as follows:

$$L_r = \frac{K_m K_i \rho I \sqrt{t}}{165 + 0.25\rho_s} \qquad (9)$$

If this is greater than the length of grid conductors plus ground rods provided in the preliminary design, more grid conductor should be provided in the design to bring touch voltages inside the grid area within safe limits.

The maximum step potential can next be checked, using equation 5. It should be, and usually will be, within the permissible limits derived from equation 3.

In addition to the foregoing, touch contacts involving "transferred potentials" may often be possible. That is, one standing in the ground mat area might be able to touch a conductor grounded only at a point remote from the station; or one standing on the ground remote from the station might be able to touch a conductor grounded only to the station grid. The shock potential then might equal the full potential rise, IR, of the ground grid, as shown in Fig. 4.

The literature describes several methods for computation of resistance when resistivity and grid geometry are known. From this resistance, and the computed short-circuit current, the maximum value of transferred potential, IR, can be determined.[1]

Where dangerous transferred potentials cannot be avoided, it is important to provide adequate insulation or barriers and to protect personnel from contact. An inventory of special danger points should then be made, such as communication circuits, rails, pipes, auxiliary buildings, switch operating handles, fences, etc.

Where a check of the normal grid design indicates that shock hazards still exist, one or more of the following corrective measures may be taken:

1. Decrease in the total resistance by increasing ground area occupied, or by adding rods or wells, chemical treatment, etc. These measures will decrease resistance and, hence, the maximum transferred potential, but will not necessarily be effective in solving local gradient problems.

2. Improvement of gradient control by closer spacing or more effective location of grid conductors.

3. Making ρ_s of a higher order than ρ by addition of high-resistivity surface layer (e.g., crushed rock) to increase resistance in series with body. This can often effect a major improvement.

4. Provision of alternate path for part of ground current, e.g., overhead ground wires. (This may increase hazard along line, however).

5. Limitation of short-circuit current (if practical, and if the gain from this will not be offset by slower fault-clearing time).

6. Barring of access to those areas where gradients cannot readily be reduced to safe values.

After construction, ground resistance should be measured and compared with the computed value. If substantially higher than computed, transferred potential hazards may need re-examination. This would also imply that the resistivity values assumed in computations were either in error or not typical of over-all conditions. New and more extensive resistivity measurements may then be indicated. Better yet, one can load the mat with about 100 amperes of ground current, simulate the body with an artificial resistance, and then actually measure, for different points of contact around the station, the body current which would flow per ampere of short-circuit current in the event of a fault.

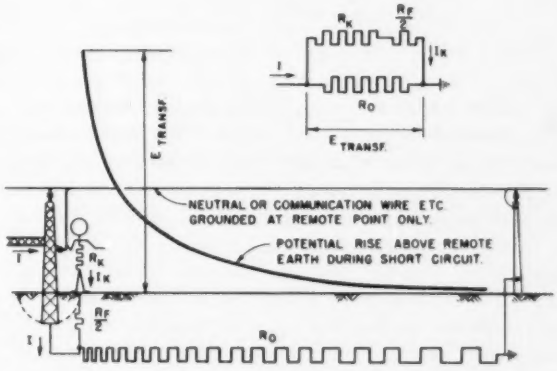

Fig. 4. Example of hazard from transferred potential.

The methods which have been outlined are intended to help engineers avoid the more dangerous situations on the one hand, and extreme overdesign on the other. In presenting the problem this briefly, some oversimplification is unavoidable. It is impossible to list all of the pitfalls into which even an experienced engineer may stumble in this complex situation. These are covered more completely in the Committee Report, and especially in the Guide, and in the articles listed in their bibliographies. The following points, however, demand emphasis:

1. Prompt clearing of faults is a major factor in safety.

2. Low ground resistance is no guarantee of safety, unless it is so low that the maximum ground current flowing through it cannot raise the ground system potential (above remote earth) beyond a value which the body can contact safely (see equation 4). In all other cases, gradients should be studied.

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The *X/R* Method of Applying Power Circuit Breakers

J. E. SKUDERNA
MEMBER AIEE

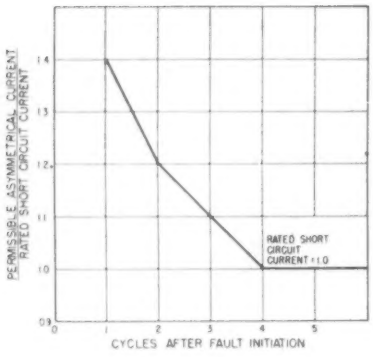

Fig. 1. Breaker asymmetrical current interrupting capabilities from proposed new basis for rating power circuit breakers.

A NEW BASIS for rating power circuit breakers was proposed at the January 1954 AIEE Winter General Meeting by the Working Group on Methods of Rating Power Circuit Breakers. This group proposed that the making, latching, and interrupting current ratings of circuit breakers be combined into one rating, rated short-circuit current, having specified characteristics which a breaker shall be able to close, carry, and interrupt with any permissible delay in tripping on a predominantly resistive or inductive circuit. To compare these specified characteristics with the decrement rates for asymmetrical fault currents on high-voltage systems, a so-called *X/R* method has been developed and is intended for use as the basis for a simplified application procedure for power circuit breakers rated on the proposed new basis.

Basis of the X/R Method. The curve in Fig. 1 defines the asymmetrical fault current interrupting capabilities of circuit breakers in terms of a reference symmetrical fault current called rated short-circuit current in accordance with the proposed new basis for rating. Rated short-circuit current is the maximum value of symmetrical fault current the breaker can interrupt at rated maximum voltage. The symmetrical fault current duty is usually determined by calculating the E/X ratio of voltage to system reactance as viewed from the breaker.

It can be shown that the decrement curve of Fig. 1 approximates the asymmetrical current decrement to a fault on a 60-cycle circuit whose X/R ratio of inductive reactance to resistance is about 15 as viewed from the fault point. A circuit breaker will have adequate asymmetrical current capabilities on systems with X/R ratio not exceeding approximately 15, provided the breaker rated short-circuit current is adequate. When system X/R ratios exceed 15, the asymmetrical fault current decays at a slower rate, thereby imposing greater duties on the breaker. The basic objective of the X/R method is to relate the breaker asymmetrical current capability at breaker contact parting time to fault current duties from circuits having X/R ratios greater than 15.

Curve *A* in Fig. 2 gives a conservative basis for application of breakers of operating time up to 8 cycles on systems of any practical X/R. For faster breakers, the results from curve *A* might be considered to be too conservative. Curve *B* can be used for conservative application of 3-cycle and faster breakers.

Calculation of 3-Phase Faults by X/R Method. Considering a network system and a 3-phase fault, the X/R ratio is simply X_1/R_1, where X_1 is the per-phase positive sequence reactance and R_1 is the per-phase positive sequence resistance as viewed from the fault point. The values of X and R are calculated independently as though the other component of the impedance were zero. Fig. 2 should be used to find the factor by which

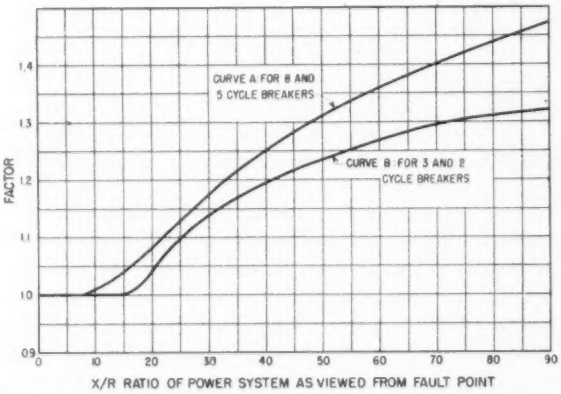

Fig. 2. Factors by which calculated *E/X* short-circuit current should be multiplied to obtain asymmetrical current duty at breaker-contact parting time.

the symmetrical fault current (E/X) should be multiplied to find the required breaker duty.

CONCLUSION

THE *X/R* METHOD provides a suitable simplified approximate breaker application procedure for industry-wide use and should be considered for use in the proposed revised version of the American Standards Association Circuit Breaker Standards (C-37).

Digest of paper 59-41, recommended by the AIEE Switchgear Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 1-6, 1959. Published in AIEE *Power Apparatus and Systems*, June 1959, pp. 328-39.

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Electrical Safety Regulations in the United States, Canada, and Europe

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A survey of the procedures of the European organization of the International Commission on Rules for the Approval of Electrical Equipment (CEE) and the activities of several European countries in the field of safety regulations. First-hand observations over the past 3 years and a summary of safety regulations activities in Canada and the United States are presented.

SAFETY regulations, as discussed in this paper, are laws, ordinances, codes, or regulations promulgated in the interest of public safety, which affect, directly or indirectly, the design, manufacture, sale, installation, use, or maintenance of electric service and equipment.

OBJECTIVES

This is basic information on (a) what safety regulations are in effect in the United States and the other countries discussed, (b) the organizational responsibilities for development of electrical safety standards and their enforcement, and (c) the facilities and methods of enforcement.

This basic information may serve as a foundation upon which may be built a continuing and enlarged record of safety regulations here and abroad as changes occur and as the field of activity broadens, both in the scope of products affected and geographically. It is believed that these data may be helpful to manufacturers and to importers and exporters of electrical products who are engaged in foreign trade. The discussions may also help in the solution of some of the industry safety problems which are common to all countries.

The information reported on European practice was gathered during visits to the various countries in 1956, 1957, and 1958. In order that the data might be up-to-date, the discussions of the activities of each of the European countries were checked with the heads of the responsible organizations and corrected to the Fall of 1958.

One purpose of this article is to show that the electrical safety regulations problem is basically the same here and abroad. Obviously, the details of such problems differ and solutions are affected by variations in law, customs, and characteristics of the countries. These basic problems fall into two broad categories:

1. Lack of uniformity of electrical safety regulations between countries, states, or political subdivisions which results in the establishment of artificial trade barriers.
2. Pressures to include quality control in safety regulations.

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DATA PRESENTED

SAFETY REGULATIONS in the United States, Canada, the United Kingdom, France, Belgium, The Netherlands, Federal Republic of Western Germany, Switzerland, Italy, Austria, Norway, Sweden, Denmark, Finland, and Spain, are discussed in varying detail, depending upon the time available for discussion with the representatives of each country. In some countries, the testing laboratories were visited, and in others, due to lack of time, they were not.

These reports discuss safety regulations in several categories. In general, they contain data on:

1. The Electrical Installation Code and how and by whom it is prepared.
2. Application of the code and who enforces it.
3. Regulations pertaining to the approval of electrical equipment, including the organizational responsibilities of the standards preparation and enforcement agencies.
4. In some cases, and not necessarily connected specifically with safety regulations as defined, a description of high-voltage and heavy-current laboratory facilities available to manufacturers and to electricity supply agencies. The relationship in many cases is close because of the government ownership, control, or operation of electric utility operations, and the consequent requirements for approval of the components of the generation, transmission, and distribution systems.
5. Other related information, such as standards for utilization voltages and frequencies, standards of quality as related to safety standards, uniformity of safety standards with those of the international standards organizations, and some particular local problems.

Because reference is made in these summaries to international standards organizations, and in the case of the United States to the American Standards Association, Inc. (ASA), brief descriptions of these organizations are included under separate headings. An attempt is also made to indicate the relationships that exist between these organizations.

For convenience, the data on utilization voltages are summarized, as are the data on adherence of local safety standards to those of the CEE. This latter summary is of necessity general, as it would be impractical to attempt to give the technical details of variances in this paper.

ELECTRICAL INSTALLATION CODES

ALL OF THE COUNTRIES INCLUDED in this study have an installation code or standard governing the installation of electric equipment. The scopes of application vary to some extent, but they all apply to residences, small commercial and industrial installations, and places of public assembly. It is generally assumed that large industrial and commercial installations, and installations in monumental, governmental, and institutional buildings are designed and made under competent engineering supervision. In any event, the considerations entering into the approval of such installations do not lend themselves readily to detailed codification, but require engineering analysis.

The installation codes vary from those of the United Kingdom, for example, which are written broadly in terms of safety performance, to those in the United States and Canada, which are quite detailed in construction requirements. The installation codes of the European countries generally follow the more general pattern of that of the United Kingdom, expressing their requirements in terms of basic safety principles, practices, and performance.

There appears to be some relationship between the general codes of the European countries and the more specific and detailed codes of the United States and Canada based on enforcement authorities. Generally speaking, in Europe, all installation inspections are conducted under the general supervision of a national inspectorate, which fixes authority and responsibility. Those inspections carried on by the utilities, which are owned and operated by, or most closely supervised by the national government, are recognized by the public, the government, and industry as informed and authoritative. The esteem in which authorities are held is such that their judgment is seldom questioned. If it is questioned, the electrical inspectorate is the deciding authority. In the United States particularly, the respect for local or state governmental authority sometimes leaves much to be desired. Coupled with the fact that the importance of the position of the electrical inspector in the United States is often not given appropriate recognition by his local and state governments, public respect for his competence and authority suffers. We firmly believe that the electrical inspection profession in the United States deserves a great deal more support, co-operation, and recognition than it now receives from government, the electrical industry, and the public.

Another fundamental difference lies in the authority behind the code. In Europe, when installation codes are applied, they are given the force of law by federal government edict and are applicable uniformly throughout the country. Here, and in Canada, they are voluntary codes which are given the force of law by state or provincial laws, or municipal ordinances. The states, provinces, and municipalities may add to or detract from the National Electrical Code or the Canadian Electrical Code, or they may write their own codes. This obviously leads to confusion. While the local deviations from the nationally recognized codes are relatively few, many of them result in unnecessary trade barriers to the use of recognized materials and products. There is no centralized federal government control. We do not advocate any, as we believe that such differences as do exist can be resolved through sound engineering consideration of each problem.

Table I. Safety Code for Electrical Installations in Users' Premises

	Developed by			Enforcement			
Country	Nat'l Gov't	Organization Representing Gov't, Power Suppliers Mfrs. etc	Voluntary	Nat'l Gov't	Power Suppliers	Local Gov't	Others
United States		NFPA—ASA	B		C	A	C
Canada		Canadian Standards Association (CSA)	B			A	
United Kingdom		Institution of Electrical Engineers (IEE)	A		B		C
France	U	Union Technique de L' Electricite (UTE)	B		C	C	
Belgium	U	Comite Electrotechnique Belge (CEB)		C		A	C
Netherlands	U	Netherlands Electro Technical Committee (NEC)		C		A	
Western Germany		Verband Deutscher Elektrotechniker (VDE)				A	
Switzerland		Schweizerischer Elektrotechnischer Verein (SEV)		U		L	
Italy		Comitato Elettrotechnico Italiano (CEI)		C		A	
Norway	U	Industry-Gov't Com.		C		A	
Sweden	U	Royal Board of Trade		A		L	L
Denmark	U	Electrical Board		A		L	L
Finland	U	Industry-Gov't Com.		L		A	A
Austria		Assn. of Electrical Engineers				A	
Spain		X		L		A	

Key: U = Universal; A = Prevailing; B = Common; C = Occasional; L = Limited

Table I illustrates some of the important points, a few significant trends and differences.

In many of the European countries, the electrical installation codes are developed by or directly under the authority of the national governments. In most cases, as indicated in the second column, government-sponsored committees, or established industry-government organizations, are assigned the task of developing the standards or codes. This contrasts with the situation in this country, the United Kingdom, and a few of the European countries, where private or professional organizations or associations do the job.

Of particular interest is the trend of enforcement by the power suppliers. It is difficult to show graphically the variations in enforcement responsibilities. Take, for example, the National Electrical Code in the United

Table II. Approval of Electrical Equipment

Country	Mandatory	Voluntary	Nat'l Gov't	Industry-Gov't	Other	Standards Guided by CEE	Standards Mark	Safety Standards Include Quality
United States	A				A		U/L	
Canada	A			A			CSA	
United Kingdom		A			A		BSI	
France		A		A		C	NF-USE	B
Belgium		A		U		C	CEBEC	A
Netherlands	L	B			A	A		
W. Germany		B		L		B	VDE	
Switzerland	U			L		A	SEV	C
Italy		A		L		C	IIMQ	A
Norway	A			A		A	N	
Sweden	A			A		A	S	
Denmark	A		A			B	D	
Finland	A		A			B		
Austria		A	A			B		
Spain	A				A			

Key: U = Universal; A = Prevailing; B = Common; C = Occasional; L = Limited

States. It is a voluntary code or standard. It is given the force of law and made mandatory through state or local laws and ordinances, and is generally enforced by state, county, or municipal inspection agencies. Occasionally, however, insurance organizations and power supply companies or agencies enforce the local code in effect. It should be borne in mind that where the national code is developed by or under direction of ministries of the national government, the enforcement is delegated to agencies such as the power suppliers. As you see, there are a number of deviations, but in the main, the power suppliers are the enforcement agencies. The heading "Others" applies generally to insurance organizations.

In Table II we find a preponderance of mandatory requirements for the approval of electrical equipment and materials used by or accessible to the public. It is interesting to note the voluntary nature of enforcement in the United Kingdom. The old common-law concept that one is presumed innocent until proved guilty is applied. Where an equipment is believed to be unsafe, it may be questioned and tested. If it does not meet the recognized safety standards of the United Kingdom, the manufacturer is informed. If no heed is taken, the product may be judged unsafe and cannot thereafter be sold or used. The warning is generally sufficient and corrections are made so that the product conforms. It is interesting to note that many British and importing firms ask for and receive (at a fee, of course) certification of conformity to British Standards Institution standards from the British Electrical Development Association laboratory. Such certification is acceptable to the authorities.

UNIFORMITY OF REGULATIONS

WHILE THERE IS LITTLE DEVIATION in the requirements for electrical installations in Europe, there are some significant differences in the standards of the several countries for the approval of electrical equipment.

Presently, practically all European countries use CEE specifications as the basis for local regulations and add their own minor deviations. The problem throughout Europe is not too unlike, in some respects, the safety regulations problem in the United States between states and municipalities, but it is accentuated by national customs, national pride, and inherent individualism. While it is recognized that it may take some time to resolve these problems, some of the participants in CEE are most anxious for uniformity of regulations in these various countries.

Two important problems before CEE today are how best to expedite the work of CEE and how to facilitate its objective of uniformity of requirements between the member countries. The latter objective is recognized as of immediate importance because of the possible pressures which may be exerted by the controlling bodies of the European common market project. The possibility of an organization to replace CEE, sponsored by the common market officials to achieve such a purpose has been mentioned.

The problem of bringing the national safety standards of each of the member countries into agreement with CEE specifications has been the subject of long discussion. It has been pointed out that, until more countries accomplish this, the Reciprocal Licensing Scheme and the use of a CEE mark cannot become effective. The Reciprocal Licensing Scheme contemplates the acceptance by all participating countries of any electrical product within the scope of CEE standards when it has been tested and approved by three of the countries, including the one in which the product is produced. The degree of deviation is illustrated in the column 6 of Table II.

Some of the deviations from the CEE specifications are quality requirements. In some cases as shown in the last column, quality requirements are suggested for incorporation in the CEE standards. The representatives of some of the countries believe that they have an obligation to assure the public satisfactory performance of equipment, as well as its safety. Pressure from consumer groups in several European countries stress particularly the limited income level of the general public in relation to the cost of appliances, with emphasis on major appliances. The purchase of a major appliance presents a considerable economic problem for most people. Poor performance can result in near calamity to the family. Unfortunately, poor quality major appliances have been promoted and sold. In reviewing the standards of the European countries, it is apparent that some include quality provisions in addition to safety, and these quality provisions are mandatory.

While it is the objective ultimately to carry the CEE specifications into the International Electrotechnical Commission (IEC) for recognition as international standards, this may involve some difficulties because the IEC National Committees are not in all cases the same committees as the CEE National Committees; consequently, there may be disagreement between the two committees within individual countries.

However, in the interest of international trade, it is recognized that general agreement on the fundamentals

Table III. CEE Publications

Country	Radios	Rubber Ins. Cords & Cables	Edison Base Lampholders	Cartridge Links Min. Fuses	Fence Controllers (Mains Oper.)	Fence Controllers (Mains Oper. With Metal Enclos.)	Fence Controllers (Battery Operated)	Plugs and Socket Outlets	Motor Operated Appliances	Cooking & Heating Appliances	Flourescent Lamp Auxiliaries	PVC Insulated Cords & Cables	Switches (Wiring Device)	Specialty Transformers (Extra low Voltages)	Fuses (Domestic & Similar Purposes)
Austria	D	I	D	I	I	I	D	D	D	I	I	D	I	Ia	
Belgium	In general identical; however, with additional quality requirements.														
Czechoslovakia	Ia	Ia	I	I	Ia		Ia	Ia	I	I	I	I	I	I	
Denmark	E	E	D	E	E	E		E	E	Ea			D		D
Finland	Ia	I	Ia	E			I	Ia	Ia	Ia	E	I	Ea		
France	E	E	E					D	D	D	Ea	D	Ea	Ea	
Hungary	In general identical; however, with additional requirements.														
Italy		D						D	D	D	D	D			
Netherlands	I	Ia	Ia	I	I		I	Ia	D	D	Ia	Ea	Ia	Ea	Ia
Norway	D	Ia	D	I	I		I	D	D	I	I	I	I		
Poland		Ia	Ia					Ia		Ia		Ia			Ia
Sweden	I	S	D	I	S	S	S	Ia	Ia	Ia	Ia	Ia	Ia		
Switzerland	S	D	S				I	D	D	D	D	D	D		
United Kingdom	S	D	D	D	S		D	D	D	D	D	D	D		
Western Germany	Ia	D	S	D	S	S	S	D	S	S	D	D	D	D	D

Key: I = Identical; Ia = Almost Identical; E = Equivalent; S = Similar; D = Different

of safety requirements is essential. Differences in these requirements, based on safety engineering principles, should be capable of being resolved. Obviously, a borderline between nations in Europe, as between states in the United States, has no effect upon the safety of a piece of equipment, its use, or the quality or effect of the supply source.

Fortunately, in the United States we have the services of the Underwriters' Laboratories, Inc. Being a nonprofit organization dedicated to the safety of the public, the results of its investigations are accepted almost without question throughout the country by inspection authorities. The safety standards of Underwriters' Laboratories, Inc., recognized by the ASA as proprietary standards, form the foundation of nationally recognized safety standards in the electric equipment field.

If the reciprocal licensing scheme and the acceptance of the CEE mark are to be effective, reasonable uniformity of standards is essential. The amount of work necessary to bring the standards into conformity with CEE standards is evident by the following analysis.

To determine the conformity of the safety standards of the CEE member countries with the existing CEE standards, a survey was conducted in 1957; the results are summarized in Table III which shows the agreement or deviation of the individual standards. Where standards are not "identical," but listed as "equivalent," either the CEE standard or the national standard is considered acceptable for the purpose of approval of the equipment concerned.

SECONDARY UTILIZATION VOLTAGES

As is evident from Table IV, there is a concerted move toward the establishment of a standard utilization voltage throughout Europe of 220/380 Y, 50-cycles. Two exceptions to this are the United Kingdom with a standard secondary voltage of 240/416 or 240/480, 50-cycles, and Norway with a 240-volt, 50-cycle ungrounded system. As the problem of the higher utilization voltages is being discussed actively in the United States, and as the European countries have had considerable experience in the use of higher voltages for domestic and commercial purposes, the safety experiences which have resulted in the development of CEE safety standards may be of considerable importance to the United States in consideration of the problem of higher utilization voltages. Results available at present are not conclusive. It may be well worth while to attempt to assemble safety data based on experience of the European countries with 220-volt-to-ground supply.

PROBLEMS OF MUTUAL INTEREST

Grounding

Probably the most frequently debated subject in the field of electrical safety in Europe, as it is in the United States, is that of the grounding of exposed metal parts of electric equipment. There are three recognized solutions to this problem, but there is little agreement as to which method is best.

1. Grounding of frames of equipment by means of a grounding conductor in the cord connected through grounding plugs and receptacles to a grounding conductor in the wiring system. In some countries (Germany and Switzerland, particularly) the wiring regulations require the installation of grounding receptacles on all new wiring. Appliances may be equipped with three conductor cords and a grounding plug. Fixed

Table IV. Standard Voltages and Frequencies

120/240 volts, 60 cycles — 120 to ground	United States, Canada Spain (limited)
120/208 volts, 60 cycles — 120 to ground	United States
240/416 volts, 50 cycles — 240 to ground	United Kingdom
127/220 volts, 50 cycles — 127 to ground	Italy (limited) France (Paris)
240 volts, 50 cycles — ungrounded	Norway
220/380 volts, 50 cycles — 220 to ground	France, Belgium, Netherlands, West Germany Switzerland, Italy Sweden Denmark, Finland, Austria Spain

appliances, such as ranges and water heaters, are generally required to be grounded, either by a separate grounding conductor or by interconnection of the frames to the service neutral. Grounding of hand appliances such as irons, hotplates, tools, motor-driven kitchen appliances, etc., may be required by the nature of their handling.

2. Double insulation or reinforced insulation is acceptable by some authorities, and preferred by others.

3. So-called "nulling" may be acceptable. This involves either the use of the service neutral for grounding, or the use of leakage current circuit breakers. The latter are, in effect, voltage-actuated circuit breakers which function when the voltage to ground on the frame of the appliance or equipment exceeds a predetermined value—generally in the order of 50 volts.

It was estimated that some 80% of the appliances in use do not conform to either methods 1 or 2. Therefore, there is a growing trend toward the use of method 3 on existing installations.

The experts are about equally divided in their opinions regarding the relative merits of methods 1 and 2.

In order that there be complete understanding of appliance classifications for application in accordance with the method of protection, the following definitions have been developed.

1. *Functional insulation* denotes the insulation necessary for the proper functioning of the equipment and for basic protection against electric shock.

2. *Protecting insulation* denotes an insulation provided in addition to functional insulation in order to ensure protection against electric shock in case of breakdown of the functional insulation. An insulating enclosure may form part of a protecting insulation.

3. *Double insulation* denotes insulation consisting of a functional insulation and an independent protecting insulation.

4. *Reinforced insulation* denotes an improved functional insulation with such mechanical and electrical qualities that it provides the same degree of protection against electric shock as double insulation. An insulating enclosure may form part of a reinforced insulation.

5. *Extra insulation* denotes either double insulation or reinforced insulation, or a combination thereof.

Appliances are classified as follows:

Appliance of Class 0 denotes an appliance with functional insulation only, but not intended to be grounded.

Appliance of Class I denotes an appliance with functional insulation and therefore intended to be grounded if necessary.

Appliance of Class II denotes an appliance with extra insulation and therefore not intended to be grounded.

Appliance of Class III denotes an appliance designed for connection to extra low voltage.

There appears to be an increasingly grave doubt in the minds of many of the safety experts in Europe about the efficacy of grounding as a means of protection of persons using portable appliances—and tools—against the hazard of shock. The trend appears to be toward dependence on double or reinforced insulation.

Licensing of Electricians and Contractors

In the discussion of the regulations in effect in the various countries, there is mention of the licensing requirements of some of them. I have not attempted to prepare an analysis of this phase of the problem because I am sure that my data is incomplete. If of sufficient interest, this can be rectified at some future time.

For the present, I observe a gradual trend toward licensing requirements both for electricians and for contractors. Such licensing requirements, where mandatory, particularly in the Scandinavian countries, are quite severe as measured against the standards in the United States. This applies both to academic as well as mechanical performance requirements.

Because of the recognized possibilities of misuse and abuse of the power to grant or withhold licenses, and the consequent effect upon the industry and the economy, every effort is made to assure impartiality in the issuance of licenses. The primary objective of impartiality is sought through the maximum separation of a competent and informed license-granting authority from pressures from government agencies and those engaged in the electrical insulation business.

Protection of Low-Voltage Services

The increase in the use of secondary networks and the resulting increases in available service fault currents have led to a considerable use of fuses to provide adequate short-circuit interrupting capacity for the protection of small air circuit breakers. Circuit breakers in general domestic use have interrupting capacities of about 1,500 amperes. Some consideration is being given to increasing the requirements for interrupting ratings, but this has not generally been done.

A considerable amount of trouble has been experienced due to a lack of co-ordination of fuse and circuit breaker characteristics. It was reported that, in many cases, customers have jumped the fuses to prevent nuisance outages. Some manufacturers are taking steps to, or already have developed circuit breakers of higher interrupting ratings.

Color Identification of Grounding Conductor

There are about as many ideas for the proper color identification of the grounding conductor as there are countries participating in CEE. It is recognized, however, that it is essential to international trade that a standard on this subject be established. The United States standard of green is gathering some support. The trend seems to be toward a 2-color combination of green and yellow, to compromise between the advocates of these individual colors. This subject is of importance to American manufacturers who are exporting assembled equipments such as machine tools, appliances, and tools.

Promotional Plans

It is encouraging that some of the European countries are directing promotional efforts toward a greater utilization of electric energy. These programs to date are largely educational and are directed toward teachers in the schools. However, some direct promotional work on electric cooking, water heating, etc., is aimed at the public. Adequate wiring, because of the higher utilization voltages, has not yet become a general problem. In general, it appears that domestic utilization of electric energy is some years behind that in the United States. The reasons appear to be largely the costs of energy and the appliances or utilization equipment which are priced considerably higher in relation to income than in the United States.

The Europeans are greatly interested in the promotional activities carried on in the United States. Much information has been supplied to them, but they should be kept well informed. By keeping them informed on our promotional activities directed toward greater use of electric energy, the promotional plans in some of the European countries may be strengthened and local markets for electrical products expanded.

OBSERVATIONS

THERE IS A CONSIDERABLE AMOUNT of data presented with this article. Some of the data will be of interest to certain segments of the electrical industry, and some to others. Certainly, one basic thought emerges from the data and the discussions—electrical safety is a worldwide problem, and no one has all the answers.

Safety standards developed in Europe have as much, and probably more influence on safety standards that are made effective throughout the world than any others. Furthermore, those safety standards have a pronounced effect upon international trade.

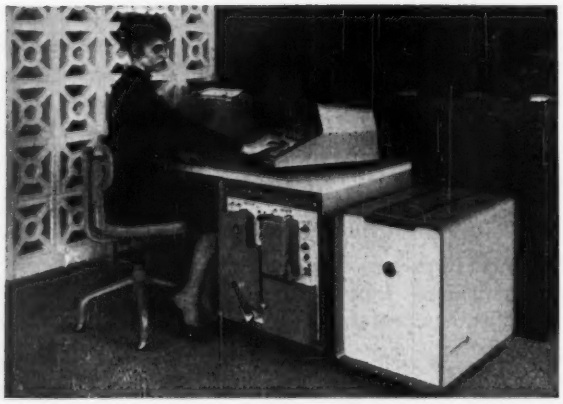
It is generally recognized that the use of electric energy by the public should be regulated in some orderly manner to assure the public of reasonable safety in its use. Throughout the paper, the recognized need for uniformity of regulations has been stressed. This need is obvious for the maintenance of a free and open market for reasonably safe electrical products so that the public may realize the maximum economic advantage in the use of the labor-saving and comfort-producing products developed by the electrical industry.

Equally important is the need for recognition of public acceptance. It is the aim of all safety-minded engineers and scientists to achieve the highest degree of safety commensurate with utility and cost of a product. Some safety experts may tend too far toward achievement of the ultimate goal of absolute safety. We know that this is impossible to attain. Therefore, regulations must not be so rigorous as to be impractical and, thus, defeat their own purposes.

It is encouraging to observe a trend toward, although by no means general acceptance of, the recognition of reasonable safety through the greater use of performance criteria instead of fixed design requirements in safety standards, both here and abroad. Obviously, it is safe performance that we seek, leaving the manufacturer freedom of design to accomplish this objective and the user a freedom of choice of competing products.

Our final observation deals with "quality." Police power may logically be applied to assure the protection of the public against hazards with which they may be unfamiliar by imposing minimum standards of performance for reasonable safety. "Quality" or "adequacy" beyond that which is needed for reasonable safety is a matter for the market place. Surely, voluntary standards of quality, particularly for specific applications and purposes, are quite in order. They should not, however, be made part of the regulatory system where conformity is a legal requirement.

Compact Computer



Autonetics' Recomp is a small, general purpose, digital computer that offers superior operational performance with exclusive size, weight, and power advantages.

Key features of the solid-state Recomp are its compact magnetic memory disk having a 4,096-word capacity, high-speed photoelectric tape reader, electric typewriter, paper tape and decimal display readout, built-in floating point arithmetic, and simplified programming. The computer weighs just 197 pounds and operates from any standard 115-volt power source.

Autonetics, electromechanical division of North American Aviation, Inc., developed the USS *Nautilus* and *Skate* inertial navigation systems.

Automatic Angle Control on Synchronous Machines

V. A. KINITSKY
MEMBER AIEE

THE ABSORPTION of reactive power by synchronous machines, particularly with low short-circuit ratio, can be difficult, and voltage control alone at the machine terminals cannot provide stable operation of the underexcited machines.

It is logical to use the power angle—angle between the equivalent field excitation voltage and the voltage at the infinite bus—as an intelligence for the excitation control of the synchronous machines operating close to their stability limit.

The block diagram of automatic control of the power angle is shown in Fig. 1. The rotor displacement angle indicator is actuated by the terminal voltage E_t, armature current I and field current I_f. The indicator shaft is coupled to the shaft of the potentiometer supplied from the d-c control bus. The voltage output of the potentiometer is proportional to the internal angle of the machine δ_i. The second potentiometer is supplied from the same d-c control bus and its voltage output is manually set proportionally to the desired power angle δ_r. The error signal proportional to the difference δ_i–δ_r is fed into the first control circuit of a magnetic amplifier.

The impulse proportional to the phase angle between the terminal voltage and the infinite bus is transmitted through the transmission line by the carrier current transmitter installed at the location of the infinite bus. This signal is received by the carrier current receiver installed at the generating station and is fed into the phase-angle meter producing a shaft deflection proportional to the phase angle. The shaft of the phase-angle meter is coupled to the shaft of the potentiometer R_s and a voltage proportional to the phase angle δ_s is applied to the second control winding of the amplifier. The bias windings of the amplifier are adjusted to provide a minimum output at $\delta_i + \delta_s = \delta_r$.

The output of the amplifier can be used for excitation control in three ways: (1) independent action on the excitation simultaneously with the voltage regulator, but contrariwise to it; (2) selective action on the excitation either by the power-angle control or by the voltage regulator; and (3) modifying the desired value of the voltage regulator setting by the angle control.

The automatic control of the power angle associated with direct- or indirect-acting voltage regulators can be used for operation of the machines in the dynamic stability region because in this stage the excitation is under the angle control with high dynamic response. Changes in the system reactances, because of line switching, bus separation, fault clearing, etc., will be considered by the phase-angle meter automatically and a manual reset of the regulator is not required.

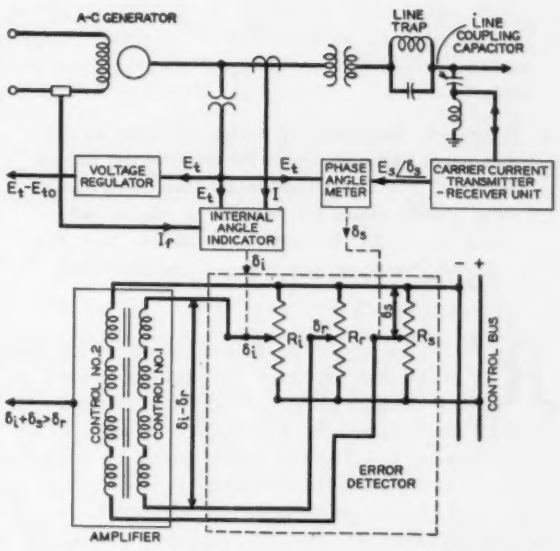


Fig. 1. Block diagram of automatic control of total angle between the internal voltage of the generator and the infinite bus.

The following conclusions can be drawn:

1. The internal angle and the phase angle are the natural parameters upon which depends the stable operation of the synchronous machine. Using these angles as the intelligence for the excitation control will permit utilization of the total capability of the machine under different load conditions without jeopardizing the operation.

2. The internal phase indicator and the phase-angle meter combined with a set of potentiometers can be used as the angle-error detector in the automatic angle control.

3. The angle control can be combined with the voltage regulator action upon the machine excitation in different ways depending on the regulator type.

4. Changes in the system reactances are taken into consideration automatically and the regulator should not be reset manually.

5. The direct- and indirect-acting voltage regulators combined with the angle control can be used for synchronous machines operating in the dynamic stability region.

Digest of paper 59-23, "Automatic Control of Internal Angle on Synchronous Machines," recommended by the AIEE Power Generation Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 1-6, 1959. Published in AIEE *Power Apparatus and Systems*, June 1959, pp. 225-31.

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Co-operative British Work on Insulating Materials

W. DEVENISH
MEMBER AIEE

Increased emphasis is being placed on co-operation between Great Britain and the United States in the investigation of insulating materials. Efforts made by two British organizations —the Electrical Research Association and the British Standards Institution—are described.

RECENTLY efforts have been made in the field of insulating materials to improve liaison between work in progress in the United States and in the United Kingdom. Therefore, it is thought that the following brief survey might prove of some interest. Obviously this survey cannot deal with the vast amount of work in progress within laboratories of commercial organizations, but it is reasonably comprehensive in respect to work organized co-operatively.

Two organizations are concerned with arrangements of this kind in Great Britain—the Electrical Research Association (ERA) and the British Standards Institution (BSI). The BSI is concerned primarily with issuing Standard Specifications for materials and equipment produced or used within the British Isles, together with test codes and codes of practice dealing with the testing, selection, installation and/or maintenance of such materials or equipment. These Standards are prepared by technical committees and considerable attention is always given to international recommendations wherever such exist. The BSI has one technical committee responsible for all insulating materials and some 40 subcommittees, many of them established for over 35 years, each committee dealing with a particular material or a very closely allied group of materials or tests. A list of the materials and tests covered by these committees is shown in Appendix I.

Where anything more than a comparatively minor investigation is needed to establish the necessary data, requests are passed from the BSI to the ERA, which deals with these and also with requests that arise from its own work. Sometimes the resulting information is passed to the BSI in the form of a short statement relating to the particular clause, etc., on which advice has been sought. On other occasions the ERA prepares proposals for the revision of an entire Standard and these are accepted by the BSI as a basis for discussion.

In this way, the ERA has been primarily responsible for the technical content of 32 of the 35 British Standards relating to insulating materials.

The ERA has a staff of some 300 and laboratories well equipped to carry out investigations of this type. In addition, it has a long-established committee organization, with representation from the whole of the electrical industry, which not only advises on the work in the ERA laboratories but undertakes a considerable amount of work within the industrial laboratories concerned. Appendix II outlines the ERA committee structure for dealing with insulation. Section A is concerned with the more immediate industrial matters, including the preparation of specifications, while Section L deals with more fundamental problems relating to solid and gaseous insulation. Section E deals with both aspects.

In the following outline of work currently in progress, unless it is otherwise stated, this is being carried out under the aegis of the ERA.

SOLID INSULATING MATERIALS

INTEREST IN TEXTILE MATERIALS is at present mainly concentrated on the behavior of Terylene (Dacron), both varnished and unvarnished. Work has been in progress for several years to establish a suitable range of tests to assess the thermal aging properties of the material and, although it is still not possible to draw any firm conclusions, certain broad outlines have been established. Part of the investigation is, of course, concerned with the effect of hydrolysis, and this has been done on both varnished and unvarnished fabric and unvarnished yarn, the latter in an attempt to isolate the change due to the material itself.

In parallel with this investigation, work is in progress on the drafting of a specification for varnished Terylene and it is hoped that this will be incorporated into an omnibus document also including cotton, silk, and nylon.

In the existing British Standard for varnished cotton, 25 breakdown strength tests are required and five 5-position jigs, similar to those used by the American Society for Testing Materials (ASTM), are suggested. Some difficulties in conducting this test have been experienced as the result of interaction between the various electrodes. The ERA has recently prepared a document indicating how to avoid these difficulties and

A special article recommended for publication by the AIEE Electrical Insulation Committee.

W. Devenish, British liaison representative on the AIEE Electrical Insulation Committee, is with the Electrical Research Association, Leatherhead, Surrey, England.

suggesting a convenient way of arranging automatic isolation of electrodes on which failure occurs.

The ASTM corrosion liability test—in which the specimen is laid on a glass cylinder, and copper wires to which a d-c potential is applied are laid across the top—has been modified to enable sleeving to be tested by being threaded over the wires and then laid across a copper foil placed on the glass cylinder. This has proved a very searching test and, as the reduction in tensile strength of the copper wire as the result of corrosion is determined quite readily by normal techniques, a numerical assessment of corrosion properties has been obtained. The basic principle is now being applied to other materials.

Recent work on papers for insulating purposes has been restricted to those used in capacitors and, arising out of an occasion on which considerable trouble was caused by harmful impurities which were not water soluble, a test has been developed in which a trichlorethylene extract is used. This again enables a reduction in resistivity to be assessed numerically.

Insulating varnishes have been investigated by means of various types of coil, the performance of the varnish being assessed by mechanical bonding of the coil after sectioning or by the ingress of moisture causing capacitance and "tan δ" changes in the windings of the coil. In addition, a bonding test has been developed in which the bond strength is measured in a normal tensile strength tester.

In the course of the investigation using coils, differences in performance of coils with nominally identical enamels were established, as well as evidence of difference in self-bonding characteristics.

Work has been in progress for a number of years to establish the interaction between various impregnating varnishes and transformer oil.

Work on sheet materials has been concerned mainly with the development of new Standards and the revision of existing ones; the materials dealt with being nonignitible and self-extinguishing boards with asbestos cement base, press paper and pressboard, phenolic-bonded asbestos paper sheets, and phenolic-bonded cellulose paper sheets and tubes. In all these materials particular attention has been given to the international recommendations for standard conditioning, water absorption, and insulation resistance tests.

The International Electrotechnical Commission (IEC) request that the American proposals relating to twisted wire aging tests on enameled wires be examined has resulted in a series of "round robin" tests following in every detail the American recommendations. In one series of tests there appeared to be doubt as to whether a straight line was the appropriate way to connect the results, and a curve, showing reduced time at lower temperatures, appeared to fit the experimental results more satisfactorily. Further tests at low temperatures however, have changed the picture and a straight line now seems likely to be satisfactory..

The ERA recommendations for methods for determining impact strengths of insulating materials were drafted some 25 years ago and covered a considerable range of methods and test specimens. This field has now been reviewed and a restricted range of tests has been chosen and recommended for future use. The document includes a dissertation on the factors to be considered when selecting the test appropriate to a particular occasion.

An ASTM article[1] was found particularly interesting here in England, as the technique of using an increase in temperature of the specimen over that of the oven as the criterion of ignition had already been investigated here and found to be a promising proposal. The extension of this technique is being attempted, to deal not only with materials but with insulation taken from completed equipment. This extension, which is being explored by a committee of the BSI, is too new for its success to be estimated.

Although the ERA and many others in the United Kingdom do not entirely agree with the proposed IEC test for tracking, it has designed equipment for carrying out the test quite automatically. Control is provided of the drop size, the drop rate, the applied voltage, and the characteristics of the relay which decides the end point of the test. It is intended to carry out investigations on the effect of varying these matters in the hope of finding ways to improve the test.

Meanwhile, the BSI has been concerned with the version of the IEC test adopted by the International Commission on Rules for the Approval of Electrical Equipment (CEE), which is in the process of being introduced into British Standards. A specially formed BSI committee has been conducting "round robin" tests on an urgent basis and has made proposals for using the test to differentiate between wood-flour-filled phenolics, asbestos-filled phenolics, and high grades of track-resistant materials.

In the last few years, the ERA has surveyed British practice in the measurement of electric strength, power factor, and permittivity. The findings on electric strength have been adopted as a British Standard, the contents being in accord with the latest IEC proposals. In the case of power factor and permittivity, this stage has not yet been reached, but ERA proposals have been put to the BSI and to the appropriate working group of the IEC. The latest draft prepared for the IEC includes the majority of the ERA proposals. Through I. G. Easton, the representative of the United States on the IEC working group, the ERA proposals have also been made available to the appropriate ASTM committee.

INSULATING OILS

At the request of the IEC, an investigation was made of the influence of electrode shape on the electric strength of insulating oils; the results support the adoption of spherically shaped electrodes in any international test.

A series of inhibited and uninhibited oils have been the subject of service trials for a number of years. They

were filled into groups of nominally identical and parallel-loaded transformers. A main object of the work is to examine the merits of various testing methods which have, from time to time, been proposed for assessing the deterioration of inhibited oils in service. So far very little significant change in the oils has been indicated, although the working temperatures of the transformers have been artificially raised by heat insulation of their tanks. However, the opportunity has been used to establish and, in some cases, improve the reproducibility of some of the tests as between laboratories.

Some years back it was considered unlikely that further progress could be made in preventing the deterioration of insulating oils in service without a more fundamental knowledge of the mechanisms involved in this deterioration. Consequently, three fundamental investigations have been initiated. In one of these a new method of studying the oxidation of the low-temperature liquid phase has been developed, based on the exothermicity of the oxidation reactions. The reaction between dissolved oxygen and the hydrocarbon is induced photochemically and the heat produced is measured by means of a thermocouple and taken as a measure of the extent of oxidation. The method enables the life of the radicals involved to be calculated. It has also been possible to calculate the absolute rate constants for the propagation and termination reactions, together with the activation energies involved in each step.

The second of these three investigations has determined the kinetic relationships for the oxidation of cyclohexene and ethyl benzene, using copper acetate, acetyl acetonate, and stearate as soluble metal catalysts. The effect of these catalysts on the hydroperoxide formed has also been investigated.

The third investigation involves a comparison of the various methods now used for testing oxidation of insulating oils, as well as a more fundamental investigation of the mechanisms by which the copper affects the oil.

This work has been complemented by investigations in three industrial laboratories to compare the behavior of metallic copper and organic copper salts as catalysts in oxidation tests. The work is providing a valuable insight into the probable mechanism of oil oxidation in service, and is expected to lead to more accurate and more precise methods for the assessment in the laboratory of the probable field behavior of oils.

Since World War II, the IEC has been actively developing an international test for oxidation of insulating oil, and the United Kingdom, through the ERA, has had a particularly active group of investigators, working in some six laboratories, whose contribution has been described as the most important from any country. Efforts are continuing with the aim of reducing the duration of the test and improving its repeatability and reproducibility. Contact with the United States has been maintained through F. M. Clark, who is a member of the IEC permanent subcommittee responsible for this project.

Appendix I

BSI Committees for Insulating Materials and Tests

Asbestos Tape
Bituminous Filling Compounds
Ceramic Electrical Insulating Materials
Classification of Insulating Materials
Composite Boards for Switchboards
Ebonite
Electric Strength Tests
Insulating Sleevings
Laminated Synthetic-Resin Bonded Sheet
Man-Made Fiber Materials
Methods of Test for Permittivity and Power Factor
Molded Insulating Materials for General Accessories
Molded Material for Use at Radio Frequencies
Moldings for Use at High Temperatures
Paper
Pressboard
Pressure-Sensitive Self-Adhesive Tapes
Synthetic Resin Varnished-Paper Tubes
Tests on Finished Moldings
Tracking Tests
Untreated Cotton Tape
Varnish
Varnished Cloth and Tapes
Vulcanized Fiber

Appendix II

ERA Committees on Insulation

Section A, Solid Materials

Varnished Cloth and Sleeving
New Fabrics
Papers
New Types of Varnish
Filling Compounds
Lac
Asbestos Cement Boards
Pressboard and Vulcanized Fiber
Laminates
Enameled Wires
Fiber-Covered Wires
Self-Supporting Films and Extrusions
Mica and High-Temperature Materials
Plastics

Section E, Liquid Materials

Chemical and Physical Characteristics
Investigations for IEC
Supervision of Field Trials on Transformer Oil
Oxidation Researches
Electrical Characteristics

Section L, Materials in General

Dielectric Losses
Electric Strength
Dielectric Properties and Solid Structure
Capacitors
Electric Strength of Gases
Mechanical Properties

REFERENCE

1. Proposed Method of Test for Defining Noncombustibility of Building Materials. *Bulletin*, American Society for Testing Materials, Philadelphia, Pa., no. 220, Feb. 1957, p. 33.

INSTITUTE ACTIVITIES

Courtesy of The Port of New York Authority

AERIAL VIEW of $30 million 11-block-long International Arrival Building and Airline Wing Buildings, Terminal City, New York International Airport. The Arrival Building, with its 362,000 square feet of floor space, houses all customs, health, and immigration inspection services, as well as a restaurant and cocktail lounge, coffee shop, snack bar, barber shop, book store, florist, jewelry shop, waiting rooms, and press accommodations. The two Wing Buildings, comprising 230,000 square feet of floor space, house ticket counters, lobbies, and offices for 14 foreign-flag airlines and a consolidated service for handling passengers on other foreign-flag lines. Four double-decked arcades provide 1,000 feet of enclosed passage to 24 aircraft positions. A 4,000-foot-long open observation deck extends the full length of the buildings and arcades at the third floor level. AIEE members will be given a tour on Thursday, February 4, during the Winter General Meeting.

Winter General Meeting Will Feature One of AIEE's Largest Technical Programs

THE AIEE Winter General Meeting to be held at the Statler-Hilton (meeting headquarters) and the Sheraton-Atlantic Hotels, New York, N. Y., January 31–February 5, 1960, will feature one of the largest technical programs in the history of the Institute. The social activities, for which the Winter General Meeting is well known, will again be outstanding. A group of varied and interesting inspection trips has been arranged, closely allied with the technical sessions.

General Session

During the general session, the Institute's Edison Medal will be awarded to J. F. Fairman, vice-president of the Consolidated Edison Company of New York, Inc., for outstanding performance in improving the design of large electric power systems; for farsighted leadership in atomic power development; and for unremitting efforts to improve the engineering profession. A feature of the meeting will be the presentation of the 1959 John Scott Award to D. A. Lyon, of Woodbridge, Conn., for his invention of the method of producing the first optical coatings for the reduction of light reflection. The AIEE Prize Paper Awards will also be presented at this time. President J. H. Foote will open the session with his report to the members of the Institute.

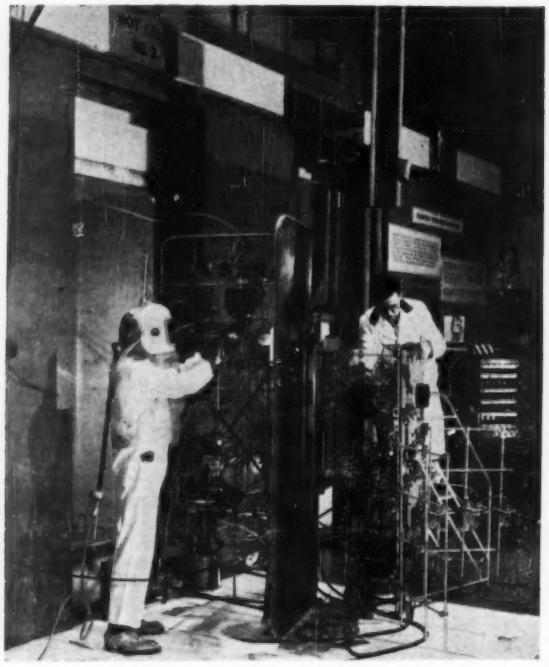
Registration Fees

The Board of Directors has found it necessary to establish a new schedule of registration fees for General Meetings. The full-week registration fee for members will be $6 and for nonmembers, $10. In addition, there will be a $2 fee for each lady. No fee will be charged for students as has been the custom in the past. This year, there will be no 1-day registration fee for anyone.

Informal Tea

This social gathering before the formal program begins has been enjoyed by more and more persons each year. This year, the informal tea will be held Sunday afternoon, January 31, from 4 p.m. to 6 p.m. in the Ballroom of the Statler. There will be no charge.

MOORE - McCORMACK LINE'S S.S. *BRASIL*. Moore-McCormack will be host to AIEE members and guests during an inspection trip planned for the Institute's Winter General Meeting on Wednesday, February 3, 1960.



PREPARATION of "hot cell" apparatus for experiment involving highly radioactive material at Brookhaven National Laboratory, Upton, N. Y. Previous experiments have contaminated the cell and the equipment in it. This makes protective clothing necessary for the worker at the left. An inspection trip to the Laboratory will be held Thursday, February 4, during the AIEE Winter General Meeting.

From 2 p.m., the registration facilities will be open for those who wish to avoid the Monday morning rush.

Hotel Reservations

Blocks of rooms have been set aside at the Statler and Atlantic (formerly McAlpin) and nearby hotels for members and guests attending the meeting.

Requests for reservations should be sent to the following hotels at the daily rates indicated:

Hotel Statler-Hilton (meeting headquarters), 7th Ave., 32nd St. to 33rd St.

Single Room	$ 8.00 to $15.00
Double Room	11.00 to 20.00
Twin Bedroom	15.00 to 25.00

Hotel Sheraton-Atlantic (formerly McAlpin), Broadway and 34th St. (also used for meetings)

Single Room	$ 8.50 to $14.00
Double Room	12.00 to 17.00
Twin Bedroom	14.00 to 18.00

All rooms have private bath and the rates quoted are subject to a 5% New York City hotel room tax.

A request for reservations should be made to only one hotel and specific reference to the AIEE meeting should be made. If the request cannot be filled, the hotel will automatically refer it to the Hotel Accommodations Committee whose duty it is to obtain a similar reservation at another nearby hotel. The hotel will confirm each request directly to the persons attending the meeting. Because of crowded conditions in New York hotels, it is suggested that reservations be made for arrival on Sunday to avoid delays in registration and the unavailability of rooms in the early morning of subsequent days.

One of the social highlights of the Winter General Meeting will be the Smoker on Tuesday evening, February 2, in the grand ballroom of the Hotel Statler. Here will be found good food, good fellowship, and top quality entertainment.

The seating capacity has been reduced from previous years to permit a greater amount of comfort and better average enjoyment by the guests. For this reason, it is strongly recommended that requests for tickets be sent in at an early date. The price of the ticket will be $11.50 and requests should be addressed to "AIEE Smoker Committee" at 33 W 39th St., New York 18, N. Y., and accompanied by checks made payable to "Special Account, Secretary, AIEE."

Dinner-Dance

The Dinner-Dance will be held Thursday evening, February 4, in the Hotel Statler. Dress will be formal. Write soon for reservations for tables for 10. The price this year is $13.50 per ticket and requests should be sent to "AIEE Dinner-Dance Committee" at 33 W. 39th St., New York 18, N. Y., accompanied by checks made payable to "Special Account, Secretary, AIEE."

Inspection Trips

A program of inspection trips of both technical and general interest has been arranged for those attending the Winter General Meeting. Since the number of persons who may be accommodated on each of these trips is limited, members who are interested are urged to make arrangements and obtain full details at the Inspection Trips desk immediately after registering. Tickets are required for all trips.

Anaconda Wire and Cable Company, Hastings on Hudson, N. Y. (Tuesday afternoon). The new EHV Cable Research Laboratory contains the finest of equipment for the development of high-voltage and extra-high-voltage cables, joints, and terminals. Major apparatus includes 750,000-volt a-c cascade transformer set; 150,000-watt-second, 3,000,000-volt impulse generator; and unique assembly of equipment to conduct simultaneous cyclic-loading overvoltage aging tests on 150-foot lengths of full-sized commercial 400,000-volt cable. Building is constructed as a high Faraday cage and is equipped with radiant heating integrated with the shielding system and atmospheric control. (See *Electrical Engineering*, June 1959, pp. 624-30.)

Astoria Generating Station, Consolidated Edison Company of New York, Inc., New York, N. Y. (Tuesday afternoon). Astoria station, newest and most efficient of Con Edison's 12 steam electric generating plants, is on the tidal East River in the Borough of Queens.

Ground was broken for the station in May 1951. Of the six generating units called for by its ultimate design, three are now in operation. Two of these are of 180 mw capacity (October 1953, March 1954) and the third (September 1958) has a nameplate rating of 335 mw. Construction of a fourth unit of 340 mw is scheduled for completion in December 1960.

Astoria is equipped to burn coal, oil, or natural gas. Of particular interest are the damper and nozzle arrangements to compensate for the station's relatively short stacks (because of nearby LaGuardia Airport), the 3-section DeLong prefabricated coal dock, and the most modern of air pollution control equipment.

The electric station is part of a 312-acre complex of utility facilities which includes a major distribution point for natural gas from the Gulf Coast used by Con Edison and other gas utilities in the metropolitan area, extensive standby and peak-load gas manufacturing facilities, the North Queens bulk-power electric switching station, a fuel oil tank farm, and Con Edison's famous 2,000,000-ton capacity coal storage yard.

Bell Telephone Laboratories, Murray Hill, N. J. (Tuesday afternoon). The group will assemble in the Arnold Auditorium at 2 p.m. There will be a talk by A. R. Brooks, publication manager, New Jersey, describing the Laboratories, their place in the Bell System, and their operations in research and development. Following this, there will be a lecture on one of the new developments in the transmission field.

Small groups will visit a cross section of different laboratories to present a broad picture of the scope of science covered by the Laboratories.

Bus leaves Statler at 12:45 p.m., returns at 5:15 p.m. Reservations $2.

Bergen Generating Station, Public Service Electric and Gas Company, Ridgefield, N. J. (Wednesday morning). Public Service Electric and Gas Company's new Bergen Generating Station is one of the company's chain of eight generating stations now in service or under construction. The initial two 290,000-kw units are the largest single units in the company's generating system and bring the total generating capacity of the system to more than 3,150,000 kw.

The new generating units are the first

AIEE Future Meetings

AIEE-IRE-ASQC-EIA Symposium on Reliability and Quality Control*
Statler Hilton Hotel
Washington, D. C.
January 11-13, 1960

Winter General Meeting*
Hotel Statler
New York, N. Y.
January 31-February 5, 1960

AIEE-IRE-U of P Solid State Circuits Conference*
University of Pennsylvania
Philadelphia, Pa.
February 10-12, 1960

Engineering Aspects of Magnetohydrodynamics Conference*
University of Pennsylvania
Philadelphia, Pa.
February 18-19, 1960

AIEE-IRE-AEC-NBS Scintillation Counter Conference*
Shoreham Hotel
Washington, D. C.
February 25-26, 1960

AIEE-ASME-II of T American Power Conference
Sherman Hotel
Chicago, Ill.
March 30-April 1, 1960
(Final date for TP—closed, ‡CP Syn. —Jan. 15, CPMs—Jan. 25)

EJC Nuclear Congress
New York Coliseum
New York, N. Y.
April 3-8, 1960

Southwest District Meeting
Shamrock-Hilton Hotel
Houston, Texas
April 4-6, 1960
(Final date for †TP—Jan. 4, DPMs—Jan. 29)

Electrical Engineering in Space Technology Conference
Hotel Baker
Dallas, Texas
April 12-14, 1960
Final date for †TP—Jan. 12, ‡CP Syn.—Jan. 26, CPMs—Feb. 5)

East Central District Meeting
Daniel Boone Hotel
Charleston, W. Va.
April 12-14, 1960
(Final date for †TP—Jan. 13, DPMs—Feb. 5)

AIEE-ASME Railroad Conference
Penn-Sheraton Hotel
Pittsburgh, Pa.
April 13-14, 1960
(Final date for †TP—Jan. 14, ‡CP Syn.—Feb. 8, CPMs—Jan. 29)

AIEE-ASME-IRE Automatic Techniques Conference
Sheraton-Cleveland Hotel
Cleveland, Ohio
April 18-20, 1960
(Final date for †TP—Jan. 19, ‡CP Syn.—Feb. 2, CPMs—Feb. 12)

Paper and Pulp Conference
University of Florida
Tallahassee, Fla.
April 21-22, 1960
(Final date for †TP—Jan. 22, ‡CP Syn.—Feb. 5, CPMs—Feb. 16)

Rubber and Plastics Conference
Sheraton-Mayflower Hotel
Akron, Ohio
April 25-26, 1960
(Final date for †TP—Jan. 26, ‡CP Syn.—Feb. 10, CPMs—Feb. 19)

Great Lakes District Meeting
Pfister Hotel
Milwaukee, Wis.
April 27-29, 1960
(Final date for †TP—Jan. 28, DPMs —Feb. 22)

North Eastern District Meeting
Sheraton Biltmore Hotel
Providence, R. I.
May 2-4, 1960
(Final date for †TP—Feb. 2, DPMs —Feb. 26)

AIEE-IRE-ACM Western Joint Computer Conference
Jack Tar Hotel
San Francisco, Calif.
May 3-5, 1960
(Final date for Initial Drafts—closed, Final Drafts—March 1)

Spring Textile Conference
Georgia Tech
Atlanta, Ga.
May 5-6, 1960
(Final date for †TP—Feb. 5, ‡CP Syn.—Feb. 19, CPMs—March 1)

AIEE-IRE-EIA-WCEMA Electronic Components Conference
Washington, D. C.
May 10-12, 1960
(Final date for †TP—Feb. 10, ‡CP Syn.—Feb. 26, CPMs—March 7)

Farm Electrification Conference
Sheraton-Fontenell Hotel
Omaha, Nebr.
May 10-12, 1960
(Final date for †TP—Feb. 10, ‡CP Syn.—Feb. 26, CPMs—March 7)

Annual Cement Industry Technical Conference
Pfister Hotel
Milwaukee, Wis.
May 17-19, 1960
(Final date for †TP—Feb. 17, ‡CP Syn.—March 4, CPMs—March 14)

AIEE-ISA-ARS-IAS National Telemetering Conference
Marimar Hotel
Santa Monica, Calif.
May 23-26, 1960
(Final date for †TP—Feb. 23, ‡CP Syn.—March 9, CPMs—March 18)

Summer General Meeting
Chalfont-Haddon Hall
Atlantic City, N. J.
June 19-24, 1960
(Final date for †TP—March 21, ‡CP Syn.—March 31, CPMs—April 15)

Pacific General Meeting
El Cortez Hotel
San Diego, Calif.
August 8-12, 1960
(Final date for †TP—May 10, ‡CP Syn.—May 20, CPMs—June 3)

Aero-Space Transportation Conference
El Cortez Hotel
San Diego, Calif.
August 8-12, 1960
(Final date for †TP—May 10, ‡CP Syn.—May 20, CPMs—June 3)

AIEE-ASME Engineering Management Conference
Morrison Hotel
Chicago, Ill.
September 14-16, 1960
(Final date for †TP—June 16, ‡CP Syn.—July 1, CPMs—July 11)

AIEE-ASME National Power Conference
Bellevue-Stratford Hotel
Philadelphia, Pa.
September 21-23, 1960
(Final date for †TP—June 23, ‡CP Syn.—July 8, CPMs—July 18)

Fall General Meeting
Morrison Hotel
Chicago, Ill.
October 9-14, 1960
(Final date for †TP—June 10, ‡CP Syn.—July 21, CPMs—Aug. 5)

1961 Winter General Meeting
Hotel Statler
New York, N. Y.
January 29-February 3, 1961
(Final date for †TP—Oct. 31, ‡CP Syn.—Nov. 10, CPMs—Nov. 15)

*Final date for submitting papers—closed

†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
DPMs—District Manuscript
(District Paper Synopses should be directed to the District Meeting Committee)

Transactions and conference papers must conform to the requirements in *Author's Guide*. For a copy, write to E. C. Day, AIEE, 33 W. 39th St., New York 18, N. Y.

of their type in the world. Each unit consists of two shafts, rotating at 3,600 revolutions per minute, with identical electric generators on each shaft. The most important feature of the design is the virtual duplication of the two parallel turbine-generator shafts, effecting economies in manufacturing, installation, and maintenance costs.

The mammoth boilers, each producing 1.9 million pounds of steam per hour at 1,100 F and 2,350 pounds per square inch pressure, consume 4,000 tons of pulverized coal per day. This means that year in and year out the equivalent of an 80-car train of coal will have to be received, dumped crushed, and pulverized every day.

The output of the generators is stepped up from 18,000 to 132,000 volts by two 340,000-kva transformers, and then sent across the New Jersey Turnpike to Bergen Switching Station. From there it is sent out over the transmission system.

Brookhaven National Laboratory, Upton, Long Island, N. Y. (All day Thursday). The facilities at this location are operated by Associated Universities, Inc., under contract with the Atomic Energy Commission, and constitute the Northeastern center for nuclear research and development in the fields of physics, chemistry, biology, medicine, and engineering. Among the important exhibits which members will see are the atomic pile and the cosmotron. A complete tour has been arranged in great detail, and competent guides, engineers, and scientists will be on hand to explain fully the extensive facilities and exhibits which have been erected at this vast site.

Bus leaves Statler at 8:00 a.m., returns at 5:30 p.m. Reservations $6.

Fairchild Camera and Instrument Corporation, Syosset, Long Island, N. Y. (Thursday afternoon). The Defense Products Division of Fairchild Camera and Instrument Corporation is engaged in the design and production of systems, subsystems, test instrumentation, reconnaissance cameras and processing equipment, specialized engineering, research and development in the fields of reconnaissance, missiles, satellites, drones, data gathering, processing and transmission, radar, infrared and nucleonics.

Tour will include a briefing on engineering work in progress by an engineering executive and visits to selected areas including the environmental test laboratories, manufacturing and assembly areas, and the division's new Physical Chemistry Laboratory where basic research is being conducted in chemical physics and new methods for recording images.

Ford Motor Company, Mahwah, N. J. (Thursday afternoon). The Mahwah Plant, one of 16 assembly plants operated by the Ford Division of Ford Motor Company, started operations on July 16, 1955, as the largest automobile and truck assembly plant in the world.

A 1-story building, 2,115 feet long and 792 feet wide, provides 1,714,050 square feet of manufacturing space and a 10,800-square-foot quality control laboratory. Fronting the plant structure is a 2-story administration building, 301 feet long by 58 feet wide, containing office space for the plant's management organization.

Engines, bodies, frames, wheels, and other car and truck components are assembled and brought together on a network of conveyors that would be more than 11 miles long, if stretched out in a continuous line.

Three major operations are handled within the plant: (1) passenger car production system, (2) truck production system, and (3) export boxing and shipping operations.

In this "stadium" of industrial skills—large enough for 35 football games to be played simultaneously—burn 31,500 8-foot light tubes. Seven spray booths and 26 ovens are required to meet production needs. The plant is capable of turning out 1,080 cars and trucks when operating on a 2-shift 16-hour day.

No cameras are permitted.

The Holophane Light and Vision Institute, New York, N. Y. (Wednesday afternoon). This lighting "clinic" is a permanently established center for the demonstration of fundamental principles of seeing and lighting, both for individuals and groups. At formal lectures, about 40 people can be accommodated comfortably. It is also in constant use as a laboratory where original research is carried on.

The demonstrations show how the eye sees, how lighting levels are determined, how colors for working spaces should be chosen, how light is controlled by optical constructions—reflectors, refractors. Visitors will be able to see the effects of shadow, diffusion, and contrast on various visual tasks, the effect of intensity on speed of seeing, and many other interesting and useful effects that they will be able to apply to their own lighting problems.

Refreshments will be served at the conclusion of the visit.

Indian Point Nuclear Electric Generating Station, Consolidated Edison Company of New York, Inc. (Thursday morning). Con Edison has built a visitors' observation and exhibit building at the site of the new Indian Point atomic electric power plant at Buchanan, Westchester County, N. Y.

The observation building, high on a bluff overlooking the plant, contains colorful, animated displays showing how atomic energy will be used at Indian Point to produce electricity. Con Edison guides will show visitors a working model of an "atomic furnace," a complete model of the plant itself, and other exhibits pointing out how Con Edison's services form an integral part of the metropolitan area's economic life.

Binoculars available on the observation deck will enable visitors to get a close-up view of the plant under construction.

The station is expected to start operations in April 1961 and will have an electrical capability of 275 mw: 163 mw from the pressurized water-thorium converter reactor, and 112 mw from two oil-fired superheaters. It will be the first unit to make use of thorium as fertile material to supplement the base fuel, highly enriched U-235.

International Business Machines Corporation (IBM), New York, N. Y. (Wednesday afternoon, Thursday morning). IBM will show their *705* Electronic Computer on which they are processing a variety of their own accounting applications. In addition, there will be a specific demonstration on the RAMAC *305* with a large unique type of storage on magnetic disks. Also there will be a discussion of new transistorized equipment such as the *1401* Data-Processing System which was announced recently.

New York International Airport, New York, N. Y. (Thursday afternoon). The trip will include an inspection of some of the most modern facilities in the central

Conference Papers Open for Discussion

Conference papers listed below have been accepted by AIEE *Transactions* and are now open for written discussion until February 29. Duplicate double-spaced typewritten copies of each discussion should be sent to F. C. Day, Assistant Secretary for Technical Papers, AIEE, 33 W. 39th St., New York 18, N. Y., on or before February 29.

56-730 **Instabilities of Push-Pull Magnetic Amplifiers Feeding the Field of an Electric Machine.** *H. F. Storm*

59-111 **Capacitance of Parallel Rectangular Cylinders.** *J. D. Horgan*

59-119 **Specifying a Pulse Transformer for Computer Use.** *R. R. Blessing*

59-134 **The Effects of Nuclear Radiation on the Electric Strength of Air.** *G. I. Duncan, J. C. Fraser, B. Valachovic*

59-236 **Technical Solutions to the Problem of Reducing Patient Dosage.** *J. E. Jacobs*

59-837 **Modified Optimum Nonlinear Control.** *T. Mitsumaki*

58-821 **A Nondestructive Breakdown Phenomenon in Selenium Rectifiers.** *A. C. English, W. H. Tobin*

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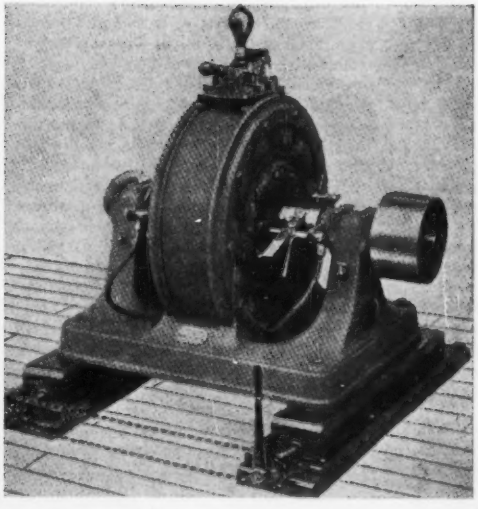

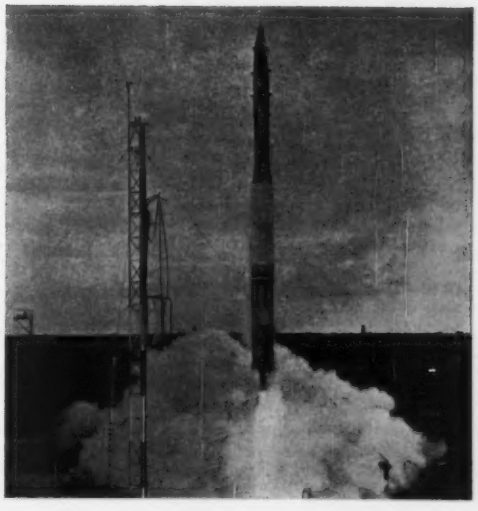

Conference Scheduled

FINALIZING plans for the 1960 International Solid-State Circuits Conference at a recent meeting of the conference national committee were: *(left to right)* William Howard, sponsors advisory committee; Lewis Winner, public relations chairman; R. F. Cotellessa, technical digest editor; T. R. Finch, program chairman; A. P. Stern, conference chairman; S. K. Ghandhi, conference secretary; Solomon Charp, conference treasurer; M. S. Corrington, chairman of the sponsors advisory committee; and Robert Mayer and Henry Sparks, local arrangements. The conference, which is scheduled for February 10-12, 1960, at the University of Pennsylvania, Philadelphia, Pa., will feature 12 evening sessions and 8 day sessions.

terminal area, including the International Arrivals Building and the central heating and refrigeration plant. Buses will be used during the tour to make stops at a central substation and a modern hangar equipped to handle the largest of the jets.

The New York Times, New York, N. Y. (Wednesday afternoon, Thursday morning). A visit to the midtown Manhattan home of what is probably the most widely read newspaper in the world, *The New York Times*, will include a view of various devices in the communications room that make it possible to have news transmitted from all over the world. Visitors will see how the news is edited as well as the mechanical operations that are required before the finished paper is put on the street.

In the composing room, type-setting machines are used to get the copy in a form necessary to create a "mat" which is sent to the pressroom. The automatic plate casting machines as well as the presses themselves are found in the stereotype department. The presses at *The New York Times* can print 375,000 48-page papers an hour.

The Okonite Company, North Brunswick, N. J. (Wednesday morning). This half-million-square-foot ultra-modern plant produces rubber and plastic-insulated wires and cables for power, control, and signaling purposes. Here also are manufactured a wide range of heavy-duty portable cords and cables for industrial and mining use.

Of special interest are the automated compound department, the submersible platform testing tanks, and the most modern methods of quality control. Materials used in addition to copper and aluminum for the conductors, are butyl rubber, natural rubber, neoprene, polyethylene and polyvinyl chloride. The latter are all materials for insulating and sheathing the cables.

Of special interest will be a demonstration of the Gooding-Slade Test Train, a unique testing device that examines cables inch-by-inch for possible flaws. This unusual equipment is a pioneer development of the Okonite Research Laboratories and has been the subject of several AIEE papers.

A new 1,100-foot-long tunnel-like structure has recently been erected to produce aluminum-sheathed cables, particularly Spir-O-line air-dielectric cables for ultra-high-frequency operation. Samples of these will be on display with other products.

Recent shipments from this plant have included several 15,000-volt polyethylene insulated submarine cables for power supply of off-shore drilling rigs used in oil well construction. Basically, this Okonite unit produces standard types of single and multiple cables for industrial plants, railroads, mining and, particularly, the electric utilities.

Bus leaves Statler at 8:15 a.m., returns at 12:45 p.m. Reservations $2.

Radio City Music Hall, New York, N. Y. (Tuesday morning). This ever popular trip has been scheduled again. Spectacular stage shows distinguished by unique lighting effects have made the Radio City Music Hall an outstanding attraction for visitors from all over the world. Members will see the backstage facilities as well as unusual features, such as revolving sectionalized stage, elevating orchestra pit, motorized curtains, and the multitude of electric and mechanical controls which are required for the special stage and lighting effects.

Rambusch Decorating Company, New York, N. Y. (Tuesday afternoon). The most diversified representation of artistry and craft work is found here. Designers, craftsmen, and lighting engineers work in complete shops and studios under one roof to serve architects and decorators with all phases of original design and execution of the decorative arts. Working in metal, wood, marble, glass, plastic, terra-cotta, and with light, paint, and mosaic, using all types of carving, paneling, and finishing equipment, skilled artisans create anything from medallions, candlesticks, and altars, to murals, statues, and great stained, polished, or carved glass windows, using the most original lighting effects.

Some of Rambusch's many creations are: the lighting of the St. Louis Air Terminal Building, carved plate-glass windows in St. Thomas Moore Chapel of Yale University; bronze sculpture for the *S.S. United States;* the United Nations Metal Map in the World Assembly Hall; sand-blasted tinted glass in the U.S. Coast Guard Academy Chapel, New London, Conn.; and the colored maparium glass enamel sphere of the Christian Science Publishing House, Boston, Mass.

Underwriters' Laboratories, New York, N. Y. (Wednesday morning). The Laboratories, sponsored by the National Board of Fire Underwriters, are operated for service, not for profit. They examine and test for public safety, write standards for safety, and control identification of their tested items, with markers, labels, lists, and listing cards.

The New York Laboratories test electric equipment and fire alarm and signaling apparatus.

The tour will include a short color movie showing some of the spectacular tests in slow motion. Interesting tests, such as destruction of new television sets, as well as routine tests will be programmed.

The Underwriters' Laboratories is a foremost safety testing laboratory whose clients operate 6,500 plants turning out an estimated 1 billion safeguarded articles each year.

United Nations General Assembly Building, New York, N. Y. (Tuesday morning). The guided tour will take slightly over 1 hour, covering various special facilities and functions of this building and descriptions of special details. Includes a trip through the Visitors' Gallery of the General Assembly Hall if the Assembly is in session. (Present U.N. schedule lists committee sessions only, and admission tickets at no charge will be available for optional group attendance after lunch about 2 p.m. Arrangements may be made for group luncheon (not included in tickets) in the Delegates Dining Room. The lunch is recommended but optional.

(The site of the new United Engineering Center will be pointed out, opposite the north end of the United Nations Plaza.)

S.S. Argentina, Moore-McCormack Line, New York, N. Y. (Wednesday afternoon). An interesting tour of the newest luxury passenger liner of the Moore-McCormack Line has been arranged. This 22,590-ton ship commissioned in December 1958 has fully air-conditioned luxury accommodations for 557 passengers in 182 modern staterooms. Her ports of call include Rio de Janeiro, Montevideo, Buenos Aires, Barbados, and Trinidad.

The electric features of the ship in-

clude three turbo-generators with an aggregate capacity of 4,125 kw at 80% power factor. The 10,047-rpm turbines drive the generators at 1,200 rpm through reduction gears.

Visitors will inspect the ship's electric facilities after hearing a brief talk on their significant features. A concurrent program and short inspection featuring interior decorations of staterooms and lounges has been arranged for the ladies. A social hour on board will follow the tours.

Ladies Entertainment

The Ladies Entertainment Committee extends a cordial welcome to ladies attending the Winter General Meeting. An interesting program has been planned for the week.

Ladies Headquarters and Hospitality Room in Washington Room of Hotel Statler will be open *Sunday afternoon* from 2:00 until 4:00 p.m. and every day during the week.

Coffee Hour in Ladies Headquarters will be each morning Monday through Friday.

The program is as follows:

Monday afternoon—A Get-Acquainted Tea courtesy of Phelps Dodge Copper Products Corporation.

Tuesday—A morning tour of the new Guggenheim Museum with luncheon at the Terrace Room of the Metropolitan Museum and an opportunity to visit English and French Rooms of the latter museum. Tour limited to 90. Tickets for transportation and admission to Guggenheim Museum $2. A meeting of the Ladies Auxiliary from 2:30 to 4:00 p.m. in Ladies Headquarters. At 6:30 p.m. the Ladies Dinner preceded by a cocktail hour courtesy of Waterbury Company, Inc., Cable Service Division and followed by entertainment courtesy of I-T-E Circuit Breaker Company. Dinner tickets $8.

Wednesday—A morning tour of the Design Center for Interiors with lunch at a nearby White Turkey Restaurant. Tour limited to 90. Tickets including transportation and luncheon $4.

Thursday—Breakfast at B. Altman's Store with a preview of spring millinery. Tickets $1.75. A luncheon and Fashion Show at the Waldorf-Astoria Hotel. The fashion show is by courtesy of Anaconda Wire and Cable Company. Luncheon tickets $5.75.

Friday—Informal tours of the United Nations Building and the new Steuben Glass Store.

Registration: Ladies register with their husbands and obtain badges before getting tickets at Ladies Headquarters for events of the Ladies Program. Ladies Registration fee $2.

Winter General Meeting Committee

Members of the 1960 Winter General Meeting Committee are: R. T. Weil, Jr., chairman; R. W. Gillette, vice-chairman; J. J. Anderson, secretary; J. R. Kerner, budget co-ordinator and AIEE vice-president for District 3; C. T. Hatcher, chairman, Technical Operations Department; C. F. Savage, public relations; W. G. Vieth, general session; M. Lennig, hotel accommodations; F. P. West, registration; H. G. Koch, inspection trips; T. W. Bartlett, monitors; D. Halloran, smoker; E. J. Doyle, dinner-dance; Mrs. D. M. Quick, ladies entertainment; and D. M. Quick, ex-officio member (past-chairman).

Tentative Technical Program

Monday, February 1

9:00 a.m. Infrared Devices

CP.* Infrared Detection System. *R. F. Maxwell, Jr.*, Westinghouse Electric Corporation.

CP.* An Image Converter for Thermal Radiation. *M. Garbuny, T. P. Vogl, J. R. Hansen*, Westinghouse Research Laboratories.

CP.* Copper-Doped Germanium as a Target Material for an Infrared Camera Tube. *R. W. Redington, P. J. van Heerden*, General Electric Company.

CP.* The 7427—A New Photoconductive Cell. *D. D. Mickey, T. A. Soileau*, General Electric Company.

9:00 a.m. Electric Heating

9:00 a.m. Electronics

CP.* Analysis and Synthesis with the "Complete" Equivalent Circuit for the Wide-Band Transformer. *T. R. O'Meara*, Hughes Aircraft Company.

59-120. Electronic Transformer Design by Digital Computers. *L. F. Deise, W. Etchison, R. Lee*, Westinghouse Electric Corporation (Re-presented for discussion only).

CP.* Tentative Proposed Standard for Low-Power Wide-Band Transformer. *P. R. Munk*, Bell Telephone Laboratories.

CP.* Tentative Proposed Standard for Electronic Power Transformers. *S. T. Maunder*, General Electric Company.

9:00 a.m. Land Transportation

60-25. Train Performance Calculated by Digital Computer-Supplemental Programs. *J. E. Hogan*, Pennsylvania Railroad Company.

60-47. A Digital Computer Simulation of Single Track Railroad Operation. *R. T. Coupal, L. L. Garver, W. R. Smith*, General Railway Signal Company.

CP.* Semiconductor Locomotive Excitation Control Developments. *T. T. Means, W. B. Zelina*, General Electric Company.

9:00 a.m. Storage Batteries

CP.* Characteristics of Nickel-Cadmium Sealed Cells. *M. Golben*, Gould National Batteries, Inc.

CP.* Characteristics of Nickel-Cadmium Batteries. *A. Fleischer*, T. A. Edison Division, McGraw-Edison Company.

CP.* Aircraft Storage Batteries. *W. J. Hamer*, National Bureau of Standards.

CP.* Storage Batteries for Military Vehicles. Power Sources Division, U. S. Army Signal R & D Laboratory.

CP.* A Constant Voltage Battery Charger. *C. Leet*, Electric Storage Battery Company, *W. Zug*, Electric Products Company.

60-51. Lead-Acid Storage Batteries in Telephone Service. *R. C. Shair*, Gulton Industries, Inc. (formerly with Bell Telephone Laboratories, Inc.).

9:00 a.m. Switching Surges and Transients

60-92. Switching Surges on Energizing a Transformer Terminated Line. *I. B. Johnson, A. J. Schultz*, General Electric Company.

CP.* Switching Surges—Part I. A Report by an AIEE Working Group. *I. B. Johnson*, General Electric Company.

CP.* Selection of Switching Surge Reference Wave or Waves for Use in Future Standardization. *P. L. Bellaschi.*

CP60-184. Determination of Transient Recovery Voltages on the Detroit Edison System. *A. K. Falk*, Detroit Edison Company; *H. L. Smith, B. L. Lloyd*, Westinghouse Electric Corporation.

9:00 a.m. Electrical Grounding as Related to Underground Corrosion and Cathodic Protection

60-4. The Effect of Electrical Grounding Systems on Underground Corrosion and Cathodic Protection. *B. Husock*, Harco Corporation.

CP.* Power System and Equipment Grounding in Conformance with Cathodic Protection Practices. *R. G. Medley, K. R. Gosnell*, Union Carbide Chemicals Company.

CP.* Grounding, Bonding, and Cathodic Protection of Pipe Line Pumping Stations. *G. M. Jeffares, W. T. Robinson, Jr.*, Plantation Pipe Line Company.

CP.* Corrosion Considerations Connected with Grounding Metallic Sheath Communication Cables. *A. F. Minor*, American Telephone & Telegraph Company.

9:00 a.m. Solid Dielectrics

CP.* Irradiated Teflon FEP—Fluorocarbon Resin in a New High-Temperature Insulation. *J. C. Reed*, E. I. duPont de Nemours & Co., Inc.

CP.* Insulation System for Naval Shipboard Motors Intermittently Submersed. *C. B. Hackney*, Allis-Chalmers Manufacturing Company; *H. P. Walker*, U.S. Navy Bureau of Ships.

CP.* A New Technique Improving Electrical and Physical Properties of Inorganic Insulation. *C. H. Vondracek, E. J. Croop*; Westinghouse Electric Corporation.

CP60-85. The Determination of the Toxicity of Gases. *D. Lester*, Yale University.

9:00 a.m. Control Computers I: Applications Analysis for Control Computer Selection

CP.* Economics of Chemical Process Selection for Computer Control. *C. P. Hall*, E. I. duPont de Nemours Co., Inc.

CP.* An Approach to Dynamic Optimizing Control of the Continuous Process. *J. F. Sandelien*, Case Institute of Technology.

CP60-119. A Generalized Chemical Processing Model for the Investigation of Computer Control Processes. *T. J. Williams, R. E. Otto*, Monsanto Chemical Company.

*Conference papers will not be reprinted by the Institute; however, they may be available at the meeting at the discretion of the author.

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College President Installed

INAUGURATION ceremonies at which E. J. Stahr, Jr. (*second from right*), was inducted as president of West Virginia University were attended by W. H. Chase (*second from left*), vice-president of District 14, AIEE, who represented the Institute as a delegate to the ceremonies; Prof. M. J. Smith (*left*), secretary-treasurer of the Upper Monongahela Subsection; and Prof. E. C. Jones (*right*), vice-chairman of the Upper Monongahela Section.

CP.* The Utilization of Digital Computers in Control Loops. *L. F. Jones*, Westinghouse Electric Corporation

CP.* A Figure of Merit for the User of a Control Computer System. *L. Fein*, Palo Alto, Calif.

9:00 a.m. Power System Engineering

CP.* Short-Range Peak Load Prediction for System Planning. *W. L. Carey*, Portland General Electric Company.

CP.* The Use of Labor Force Statistics in Estimating Electric Energy Loads. *J. G. Gruetter*, Bonneville Power Administration.

CP.* Principles of Economic Dispatching for Electric Power System Operators. *H. B. Smith*, Niagara Mohawk Power Corporation.

CP.* A Digital Solution of Economic Dispatch and Interchange Billing. *F. J. Sherman, W. B. Tagen*, Boston Edison Company.

CP.* A Digital Approach to Power System Engineering—I. *M. B. Reed, G. Reed*, Michigan State University; *J. L. McKinley, H. K. Polk, R. V. Hugo, W. J. Martin*, Public Service Company of Colorado.

2:00 p.m. General Session

Tuesday, February 2

9:00 a.m. New Electron Tube Developments

CP.* A New Look at Tube Design. *E. R. Jervis*, ARINC Research Corporation.

CP.* High Purity Nickel Cathode Alloys. *R. E. Caffrey*, Bell Telephone Laboratories, Inc.

CP.* White Noise and Swept Frequency Vibration Testing as Applied to Vacuum Tubes. *H. C. Pleak*, Sylvania Electronic Tubes.

CP.* X-Ray Image Intensification with a Large Diameter Image Intensifier Tube. *W. F. Niklas*, Rauland Corporation.

CP.* Ionization Gauge for Measuring Pressures up to the Millimeter Range. *R. J. Melling*, Westinghouse Electric Corporation.

60-73. Tubes or Transistors, A Realistic Assessment. *R. E. Mae*, General Electric Company (Re-presented for discussion only).

60-74. Shall an Electron Tube or a Semiconductor Device Be Used? *E. E. Scheuneman, S. K. Waldorf* (deceased), Westinghouse Electric Corporation (Represented for discussion only).

9:00 a.m. Planning-for-Growth

CP60-137. How Economics Affects System Planning. *C. M. Stairs*, Canadian General Electric Company, Ltd.

CP60-138. Using the Digital Computer in Industrial Power System Design. *R. F. Cook, A. D. Patton*, Westinghouse Electric Corporation.

CP.* How Planning for Growth Paid Off. *E. C. Siddons*, American Cyanamid Company.

9:00 a.m. Feedback Control Systems Theory

CP60-61. An Analytical Method of Determining Pole Locations of Certain Types of Feedback Amplifiers. *R. L. Gamblin*, International Business Machines Corporation (formerly with Princeton University).

CP60-105. Rapid Determination of Approximate Closed-Loop Poles of Feed-Back Control Systems. *S. K. Basu*, University College of Technology.

60-29. Design for Minimum Probabilistic Error of Continuous Linear Control Systems Subject to Constraints. *J. Zaborsky*, Washington University and McDonnell Aircraft Corporation, *J. W. Diesel*, McDonnell Aircraft Corporation.

60-62. Comparison of Vibratory and Rotating-Wheel Gyroscopic Rate Indicators. *G. C. Newton, Jr.*, Massachusetts Institute of Technology.

60-63. Analysis of Load Transfer Oscillations in Parallel Aircraft A-C Electric Power Systems. *H. A. Kahle*, Jack & Heintz, Inc.

60-106. The Selection of Electric Winder Drives for the Paper Industry. *M. H. Fisher*, Westinghouse Electric Corporation.

59-837. Modified Optimum Nonlinear Control. *T. Mitsumaki*, Hitachi, Ltd. (Re-presented for discussion only).

59-1296. Optimization of the Adaptive Function by Z—Transform Method. *S. S. L. Chang*, New York University (Re-presented for discussion only).

9:00 a.m. Industrial Power Rectifiers

CP.* Progress in High-Power Rectifier Technology. *A. Hansen, Jr., P. J. Colleran, G. B. Farnsworth, C. E. Rettig*, General Electric Company.

CP.* Voltage Control of Silicon Rectifier Units. *C. S. Hague, K. F. Friedrich*, Westinghouse Electric Corporation.

CP60-34. Forward Voltage Drop and Power Loss in Silicon Rectifiers. *W. Luft*, International Rectifier Corporation.

CP60-35. Mechanical Rectifier Definitions. Mechanical Rectifier Subcommittee of the Industrial Power Rectifier Committee; I. K. Dortort, chairman.

CP.* Excitation Requirements for Controlled Semiconductor Rectifiers. *A. Schmidt, Jr., E. E. Moyer*, Acme Electric Company.

9:00 a.m. Land Transportation

CP60-48. The Pennsylvania Railroad Class *GG-1* Electric Locomotives. *J. W. Horine*, Pennsylvania Railroad Company; *H. S. Ogden*, General Electric Company.

CP60-49. Experiences of the Sorocabana Railway with Electrification 1943-1958. *E. D. de Toledo*, Sorocabana Railway.

CP60-23. Economic Trends Make Railroad Electrification Inevitable. *L. B. Curtis*, The Pennsylvania Railroad Company.

60-50. Virginian Railway Motor-Generator Electric Locomotive Maintenance Costs. *T. F. Perkinson*, General Electric Company.

9:00 a.m. Communications Switching Systems

9:00 a.m. Extra High Voltages

60-185. A Proposal for International Standardization of EHV Transmission Voltages. *P. Sport, H. P. St. Clair*, American Electric Power Service Corporation.

CP.* Project EHV—Technical Plan. *P. A. Abetti, D. D. Davis, J. H. Hagenguth*, General Electric Company.

CP.* Project EHV—Insulation Design. *J. G. Anderson, J. H. Hagenguth, I. B. Johnson, A. J. Schultz*, General Electric Company.

CP.* Project EHV—North Station and Portal-Type Towers. *S. Minneci, A. H. Powell*, General Electric Company; *R. E. Larson*, Aluminum Company of America; *G. E. Fortney, S. D. Alpert*, Stone & Webster Engineering Corporation.

CP.* Project EHV—Conductors, Insulators, and Conductor Accessories. *J. J. LaForest, J. Kaminski, Jr.*, General Electric Company; *R. E. Larson*, Aluminum Company of America.

60-186. Project EHV—Preliminary Corona Investigations: The Effect of Harmonics on Corona Losses. *A. H. Foley, F. Olsen*, General Electric Company.

9:00 a.m. Rotating Machinery & Relays

60-32. Survey of Induction Motor Protec-

tion. AIEE Subcommittee on Motor Protection of the Relays Committee; H. C. Barnes, chairman.

CP.* Steady-State and Transient Thermal Characteristics of a Medium Size Induction Motor. *H. B. Margolis*, American Electric Power Service Corporation; *R. M. McCoy, W. J. Martiny*, General Electric Company.

CP.* Signal Flow Graphs and Equivalent Circuits of Asynchronous Motors. *Yoa-Nan Yu*, Villanova University.

CP60-165. Equivalent Circuits and Performance Calculations of Canned Motors. *P. D. Agarwal*, University of Massachusetts.

60-166. The Pull-In Criterion for Reluctance Motors. *J. F. H. Douglas*, Marquette University.

9:00 a.m. Switchgear

60-151. Proposed American Standard Definitions Pertaining to Alternating-Current Power Circuit Breakers—37.3 and Proposed Revision of American Standard C37.4—Rating Structure for Alternating-Current Power Circuit Breakers. AIEE New Working Group on Methods of Rating Power Circuit Breakers, J. H. Vivian, chairman.

60-152. Proposed Revision of American Standard C37.5 American Standard Methods for Determining the Values of a Sinusoidal Current Wave and a Normal Frequency Recovery Voltage and Proposed Revision of American Standard C37.9 Test Procedure for Power Circuit Breakers. AIEE New Working Group on Methods of Rating Power Circuit Breakers, J. H. Vivian, chairman.

9:00 a.m. Section Representatives

9:00 a.m. Magnetic Amplifiers and Solid-State Devices

CP.* A New Power Amplifier Using a Single Controlled Rectifier and a Saturable Transformer. *R. E. Morgan*, General Electric Company.

CP.* Solid-State Firing Circuits for Trinistors. *B. Mokrytzki*, Westinghouse Electric Corporation.

CP.* Controlled Rectifier Frequency Multipliers Using Inverter Principles. *C. W. Flairty, J. D. Harnden, Jr.*, General Electric Company.

60-96. Recent Developments on Magnetic-Coupled Multivibrators. *W. A. Geyger*, U.S. Naval Ordnance Laboratory.

9:00 a.m. Liquid Dielectrics

CP.* A Study of the 1959 International Symposium on Conduction and Breakdown in Liquid Dielectrics. *A. H. Sharbaugh, P. K. Watson*, General Electric Company.

CP.* Parameters for Predicting Gassing of Oils Under Electric Stress. *S. C. Bartlett*, Sun Oil Company; *R. D. Blodgett*, Okonite Company.

CP.* Electrical Stability of Insulating Oils. *E. Eich*, Anaconda Wire & Cable Company; *G. Feick, A. Olds*, Arthur D. Little Company.

CP60-84. A Bubble Theory for Electric Breakdown of Liquid Dielectrics. *K. C. Kao*, English Electric Company, Ltd.

9:00 a.m. Control Computers II: Comparison of Incremental (DDA) and Whole-Number (GPC) Arithmetic Computers

CP.* Introduction to D.D.A. *E. Braun*, Genesys Corporation.

CP60-120. The Relative Merits of Incremental and Conventional Digital Computers in Real-Time Control. *S. M. Shackell*, Stevens Institute of Technology (deceased); *J. G. Tryon*, University of Alaska (formerly with Bell Telephone Laboratories, Inc.).

CP60-121. A Comparison of Whole Value and Incremental Digital Techniques by the Use of Patch Panel Logic. *R. W. Waller, F. E. Brinckerhoff*, Computer Control Company, Inc.

CP60-122. A Comparison of Digital Differential Analyzer and General Purpose Equipment in Guidance Systems. *M. M. Dickinson*, International Business Machines Corporation.

CP.* Results of Simulation Comparison. *G. T. Sendzuk*, General Electric Company.

9:00 a.m. Safety

60-3. Temporary Paralysis Following "Freezing" to a Wire. *C. F. Dalziel*, University of California.

CP60-171. Field Treatment in Electric Shock Cases—II. *W. B. Kouwenhoven, G. G. Knickerbocker, W. R. Milnor, J. R. Jude*, The Johns Hopkins University.

CP60-40. Threshold 60-Cycle Fibrillating Currents. *C. F. Dalziel*, University of California.

9:00 a.m. Electronics

CP.* The Effects of Transformer Parameters on Surge Voltage Transients in Rectifier Circuits. *P. E. Kolk*, Radio Corporation of America.

CP.* Ultra-High-Temperature (500 C) Electronic Transformers Part I—Design Considerations. *G. E. Walter, H. B. Harms, G. Walters*, General Electric Company; *J. F. Rippin, Jr.*, Wright Air Development Center.

CP.* Ultra-High-Temperature (500 C) Electronic Transformers Part II—Design Optimization. *G. Walters*, General Electric Company.

CP.* Alumina Power as a Potting Material for Electronic Power Transformers. *L. W. Kirkwood, R. S. Key;* Bell Telephone Laboratories, Inc.

2:00 p.m. Ceramic Electron Tubes and other Developments

CP.* A New, Rugged, Ceramic Pencil Tube for Class C Service. *C. Gurwacz*, Radio Corporation of America.

CP.* A Small, Rugged Ceramic Tube for Low-Level Amplifier Use. *J. M. Connelly*, General Electric Company.

CP.* A Ceramic Hot Cathode Gas Rectifier for Use in High-Temperature Applications. *W. J. Kearns*, General Electric Company.

CP.* Rare Earth Hydride Reservoirs. *N. L. Yeamans, J. E. Creedon, S. Schneider*, U.S. Army Signal Research and Development Laboratory.

CP.* Design Considerations for Modulators and Converters Using a New Miniature Beam-Deflection Tube. *M. B. Knight, J. T. Maguire*, Radio Corporation of America.

CP60-75. A New Ceramic Triode for VHF Applications. *J. D. Campbell*, General Electric Company (Re-presented for discussion only).

2:00 p.m. Planning-for-Growth

60-12. Determination of Ground Fault Current on Common Alternating-Current Grounded Neutral Systems in Standard Steel or Aluminum Conduit. *J. A. Gienger, O. C. Davidson, R. W. Brendel*, Eastman Kodak Company.

CP.* Arcing Fault Protection for Low-Voltage Power Distribution Systems. *R. H. Kaufman, J. C. Page*, General Electric Company.

CP60-139. Fused Interrupter Switchgear. *A. W. Maas*, I-T-E Circuit Breaker Company.

60-140. A New Welder Busway Distribution System. *L. E. Fisher*, General Electric Company; *R. W. Dailey*, Chrysler Corporation. (Re-presented for discussion only).

2:00 p.m. Reliability and the Systems Concept: Panel Discussion

CP.* E. J. Nucci—Department of Defense.

CP.* F. Thompson—BuAer, Department of the Navy.

CP.* A. J. Finocchi—International Telephone and Telegraph Laboratories.

CP.* D. Graham—Princeton University and Systems Technology, Inc.

2:00 p.m. Industrial Power Rectifiers

CP.* Effective Value of Direct-Voltage Ripple. *E. J. Diebold*, Perkin Engineering Corporation.

CP60-36. Transient Decay of Current through Paralleled Mercury ARC and Silicon Rectifiers. *W. R. Hodgson*, Westinghouse Electric Corporation.

CP.* Start-Up and Initial Operation of a Large High-Voltage Germanium Rectifier Equipment. *G. Choma, T. C. Ward*, Diamond Alkali Company.

CP60-39. Series Capacitors Applied to Power Rectifiers. *L. J. Hibbard, T. J. Bliss*, Westinghouse Electric Corporation.

60-14. Report of Field Tests on Aluminum Pot Line Rectifier Systems. *C. A. Langlois*, Reynolds Metals Company; *V. N. Stewart, R. P. Stratford*, General Electric Company. (Re-presented for discussion only).

2:00 p.m. Land Transportation

CP.* High-Performance Rapid-Transit Cars for the Hudson and Manhattan Railroad. *S. V. Smith*, Pennsylvania Railroad Company; *W. C. Wheeler*, St. Louis Car Company; *W. H. Wood*, General Electric Company.

CP.* New Passenger Car Equipment of the Chicago & Northwestern Railway. *J. L. Swarner*, Pullman-Standard Car Manufacturing Company.

CP.* Loading of Transportation Rectifier Substations. *L. De Koranyi*, General Electric Company.

2:00 p.m. Communications Switching Systems

2:00 p.m. Distribution Systems

CP.* Economic Analysis of Distribution Systems. *H. E. Campbell, R. C. Ender, M. W. Gangel, V. C. Talley*, General Electric Company.

60-177. Distribution System Planning through Optimized Design I.—Distribution Transformers and Secondaries. *R. F. Lawrence, D. N. Reps, A. D. Patton*, Westinghouse Electric Corporation.

60-178. Distribution System Planning through Optimized Design II—Comparative Economics of System Voltages. *R. F. Lawrence, D. N. Reps, A. D. Patton*, Westinghouse Electric Corporation.

CP60-188. Comparative Studies on the Use of Subtransmission vs. Distribution Voltages to Serve Customers' Transformer Stations. *D. T. Michael*, Cincinnati Gas & Electric Company.

CP60-187. The Economic Application of Capacitors to Distribution Feeders. *M. Maxwell*, Westinghouse Electric Corporation.

2:00 p.m. Rotating Machinery

60-21. An Analysis of Solid Rotor Machines —III Finite Length Effects. *A. J. Wood*, Hughes Aircraft Company (formerly with General Electric Company); *C. Concordia*, General Electric Company.

60-22. An Analysis of Solid Rotor Machines —IV An Approximate Nonlinear Analysis. *A. J. Wood*, Hughes Aircraft Company (formerly with General Electric Company) *C. Concordia*, General Electric Company.

60-127. A New Brushless D-C Excited Rotating Field Synchronous Motor. *G. M. Rosenberry, Jr.*, General Electric Company.

CP.* Voltage Harmonics of Salient-Pole Generators under Balanced 3-Phase Loads, Part II. *D. Ginsberg*, U. S. Army Engineering and Development Laboratories; *A. L. Jokl*, Continental Motors Corporation.

Father Presents Fellow Diploma to Son

BOTH FATHER AND SON now share the honor of "fellowship" in the AIEE, with the presentation of the Fellow diploma to J. W. Kalb (*right*), director of electrical research at the Ohio Brass Company, Barberton Division, by his father, W. C. Kalb (*left*), who himself was elevated to the grade of Fellow in 1940 while employed by the National Carbon Company at Cleveland. The diploma was presented at a meeting of the Akron Section, AIEE.

CP60-167. Unbalanced Loading of Turbine Generators. *R. L. Winchester*, General Electric Company.

CP.* A Test Report on Harmonic Excitation of A-C Generators. *F. I. Biggs, P. I. Nippes*, Elliott Company.

2:00 p.m. Switchgear

60-153. Proposed American Standard C37.10 Application Guide for Alternating Current Power Breakers. AIEE Working Group on Methods of Rating Power Circuit Breaker, J. H. Vivian, chairman.

2:00 p.m. Section Representatives

2:00 p.m. Magnetic Amplifiers

60-91. Rectifier Unblocking from a Generalized Analysis of Self-Saturating Magnetic Amplifiers. *H. C. Bourne*, University of California; *D. Nitzan*, Stanford Research Institute.

60-66. Symmetrical Frequency Multiplier Circuits. *G. W. Dick*, Bell Telephone Laboratories (formerly with University of Toronto).

56-730. Instabilities of Push-Pull Magnetic Amplifiers Feeding the Field of an Electrical Machine. *H. F. Storm*, General Electric Company (Re-presented for discussion only).

60-143. An Analysis of the Operation of the Magnetic Second-Harmonic Modulator. *B. W. Jalbert*, General Electric Company (Re-presented for discussion only).

CP60-144. 1958 Magnetic Amplifier Bibliography. AIEE Magnetic Amplifier Applications Subcommittee of the Magnetic Amplifiers Committee, D. Katz, chairman.

2:00 p.m. Control Computers III

CP60-123. Machine Tool Director; A Special-Purpose Computer for Use in Numerical Control Systems. *W. W. Knight, W. W. Straub*, General Electric Company.

CP60-124. Statistical Data Reduction and Control Systems. *E. J. Schubert*, Monitor Systems Inc.

CP.* UDOFT Computer Description. *W. Humphreys, Jr., J. Warge*, Sylvania Electronic Systems.

CP.* The Leeds & Northrup Series *3000* Control Computer Systems. *R. G. Lex*, Leeds & Northrup Company.

CP.* External Communication Consideration for an In-Line Computer. *G. Daniels*, Panellit, Inc.

2:00 p.m. Thermal Endurance

CP60-86. Factors Affecting the Aging Characteristics of Various Wire Coating Materials in Transformer Oil. *G. F. Lipsey, P. W. Juneau, Jr.*, General Electric Company.

CP60-87. Thermal Life of Varnished Glass Cloth. *C. J. Straka, E. W. Lindsay*, Westinghouse Electric Corporation.

CP60-88. Study of Thermal Deterioration of Magnet Wires by Mass-Spectrometer Method. *Y. Saito, T. Hino*, Tokyo Institute of Technology.

CP.* A Study of Normality of Distribution of Thermal Life Test Data. *J. L. Cantwell*, General Electric Company.

2:00 p.m. Electrostatic Processes

CP.* Charging of Nonspherical Particles in a Corona Discharge. *G. W. Penney, P. L. Smith*, Carnegie Institute of Technology.

CP.* Electrostatic Propulsion Devices for Space. *A. J. Gale*, High Voltage Engineering Corporation.

CP60-102. Current-Voltage Relationships. *J. B. Thomas, T. R. Williams*, Princeton University.

CP.* Turbulent Gas Flow and Electrical Precipitation. *P. Cooperman*, University of Pittsburgh.

CP60-103. Sparkover as Influenced by Surface Conditions in D-C Corona. *G. W. Penney, S. E. Craig*, Carnegie Institute of Technology.

60-33. Potentials in D-C Corona Fields. *G. W. Penney*, Carnegie Institute of Technology; *R. E. Matick*, International Business Machines Corporation (formerly with Carnegie Institute of Technology) (Re-presented for discussion only).

59-234. Power Relationships and Temperature Dependence in the D-C Corona Field. *J. B. Thomas, T. R. Williams, T. Suzuki*, Princeton University (Re-presented for discussion only).

60-2. A Theory for Space-Charge Limited Currents with Application to Electrical Precipitation. *P. Cooperman*, University of Pittsburgh (Re-presented for discussion only).

59-223. Saturable Reactor Control of Full-Wave and Bi-Phase Rectifiers. *J. B. Thomas*, Princeton University; *J. W. Drenning*, Koppers Company, Inc. (Re-presented for discussion only).

2:00 p.m. Nucleonics

CP60-148. Safety Aspects of a Pressurized Water Nuclear Reactor Power Plant and Associated Instrumentation and Control Requirements. *C. F. Obermesser*, Westinghouse Electric Corporation.

CP60-149. Preliminary Investigation of Constant Cold Leg Temperature Control. *J. M. Gallagher, Jr.*, Westinghouse Electric Corporation.

CP.* Critical Assembly Work for Enrico Fermi Reactor. *R. L. McVean*, Detroit Edison Company.

CP.* Principles of the Power Supply of 12.5 Bev Proton Synchrotron at the Argonne National Laboratory. *G. O. Calabrese*, Argonne National Laboratory.

60-150. Design of an Eddy-Current Brake for a Sodium-Cooled Nuclear Power Reactor. *R. S. Baker*, Atomics International.

Wednesday, February 3

9:00 a.m. Microwave Tubes

CP.* Suppression and Limiting of Undesired Signals in Traveling-Wave Tubes. *H. J. Wolkstein*, Radio Corporation of America.

CP.* An X-Band Periodic-Focused Traveling-Wave Tube Limiter Chain. *R. McMurrough, G. Novak, W. Caton*, Radio Corporation of America.

CP.* Experiments on a Series of S-Band Crestatrons. *J. E. Rowe, G. T. Konrad, H. W. Krage*, University of Michigan.

CP.* 1,000- to 2,000-Megacycle Electrically Tunable Magnatron. *M. Weinstein*, General Electric Company.

CP.* A Dual-Mode Pre-TR Tube. *G. Klein, M. G. Bates*, Westinghouse Electric Corporation.

CP60-76. Voltage Transients Due to ARC Extinction. *H. C. Steiner, R. W. Strecker*, General Electric Company (Re-presented for discussion only).

60-77. The "Empretron," A Mercury Pool Arc Tube Allowing Operation at Repetition Rates in the Kilocycle Range. *K. G. Hernqvist, F. H. Norman,* Radio Corporation of America (Re-presented for discussion only).

9:00 a.m. Ideas for Solving Control Systems: Panel Discussion

Moderator: L. F. Kazda, University of Michigan.

9:00 a.m. Chemical and Petroleum Industries

60-38. Application of Accepted Cable Heating Principles to Unequally Loaded Underground Duct. *R. D. Chamlee, D. E. McCall;* C. F. Braun and Company (Re-presented for discussion only).

CP.* New Trends and Wiring Methods in the Chemical Industry. *O. E. Lundelius, H. E. Wilson,* Brown and Root Inc.

CP60-52. The Application of Static Switching to the Control of Two 7,500-Hp Oil-Fired Combustion Turbines. *P. T. Carmack,* Union Carbide International Company; *E. M. Smith,* General Electric Company.

CP.* New Developments for Hazardous Locations, Class I and Class II. *R. W. Scott,* Crouse-Hinds Company.

60-16. Characteristics of Centrifugal Pumps and Compressors which Affect the Motor Driver under Transient Conditions. *H. A. Wiegand,* Ingersoll Rand Company; *L. B. Eddy,* Universal Oil Products Company (Re-presented for discussion only).

9:00 a.m. Indicating and Integrating Instruments

60-135. Thermal Voltage Converters for Accurate Voltage Measurements to 30 Megacycles per Second. *F. L. Hermach, E. S. Williams,* National Bureau of Standards.

CP.* Transistorized Footage Counter with Printout for the Paper Industry. *S. Salowe, W. J. Schmidt,* Westinghouse Electric Corporation.

CP.* A New Impulse Metering System. *C. L. Snyder, C. A. Booker, Jr.,* Westinghouse Electric Corporation.

CP60-136. An Astatic AC-DC Comparator with Wide Frequency Range. *J. Pawlat, J. Wolloch,* C. P. Goerz Company.

9:00 a.m. Marine Transportation

CP60-145. Neutral Grounding as Applied to Marine Alternating Current Systems. *R. J. McSweeney, W. A. Hall,* Gibbs & Cox, Inc.

CP60-146. Advantages of Underground Marine Electrical Systems. *A. M. Bruning, E. W. Lusby,* Westinghouse Electric Corporation.

CP60-147. *S. S. Brasil* and *Argentina* Electrical Installation. *H. E. Senger,* Moore-McCormack Lines, Inc. (To be presented on board the *S. S. Argentina* at 2:00 p.m.)

9:00 a.m. Communication Theory

CP.* Burst Correcting Codes. *D. W. Hagelbarger,* Bell Telephone Laboratories, Inc.

CP.* A New Group of Codes for Correction of Dependent Errors in Data Transmission. *C. M. Melas,* International Business Machines Corporation.

60-142. Radio Communication with Orthogonal Time Functions. *H. F. Harmuth,* Stromberg-Carlson Company.

CP.* Null-Zone Envelope Detection in Biary Systems. *J. J. Metzner, K. C. Morgan,* New York University.

9:00 a.m. Towers, Poles, and Conductors

60-53. Economics of Single and Bundle Conductors for Extra-High-Voltage Transmission. *P. A. Abetti, C. B. Lindh, H. O. Simmons,* General Electric Company.

60-189. The Effect of Tighter Conductor Tensions on Transmission Line Costs. *E. Fritz,* Potomac Electric Power Company.

CP.* Broken Wire Assumptions—A Transmission and Distribution Committee Report. *E. E. Fritz,* Potomac Electric Power Company; *R. C. Caswell,* Commonwealth Edison Company, *F. F. Farr,* Bonneville Power Administration.

CP60-190. An Analysis of Galloping Electric Transmission Lines. *W. N. McDaniel,* Baltimore Gas & Electric Company.

CP60-72. Design of Chute-des-Passes 345-Kv Transmission Line. *H. B. White,* Aluminum Company of Canada, Ltd.

9:00 a.m. Telemetering

9:00 a.m. Rotating Machinery

60-125. Impulse Testing of Rotating A-C Machines. AIEE ASA C-50 Subcommittee, J. B. McClure, chairman.

CP60-168. A Generalized Procedure for Fault Location in 2-Pole Lap Wound D-C Armatures Using A Standard Surge Comparator. *F. A. Scheda, J. J. Riley,* Westinghouse Electric Corporation.

CP.* Plyseal. *H. E. Mazanek, T. J. Gair,* General Electric Company.

CP.* Experience with D-C Testing of Machine Windings. *E. Westgaard,* Technical University of Norway; *J. Sletbak,* Norwegian Research Institute of Electricity Supply.

CP.* Puncture Hazard Involved in D-C Testing of Large Synchronous Machines. *L. G. Virsberg,* ASEA Research Laboratories.

58-1391. Accelerated Voltage Endurance Tests. *R. C. Rhudy, H. E. Mazanek,* General Electric Company (Re-presented for discussion only).

9:00 a.m. Switchgear—Substations

CP.* Use of Rod Gaps for Substation Protection. *T. F. Watson, R. Hiatt,* Commonwealth Associates.

60-205. Insulation Co-ordination of Circuit Breakers during Operation. *A. L. Streater, W. R. Wilson,* General Electric Company.

CP.* Power Circuit Breaker Insulation Co-ordination. *C. E. Asbury,* Commonwealth Associates; *O. Naef,* American Electric Power Service Corporation.

CP.* Automatic Line Transfer Equipment for Supervisory Systems with Direct Wire Interconnecting Channels. *L. E. Monacci,* Consolidated Edison Company of New York; *W. Hodges, A. R. Christman,* General Electric Company.

9:00 a.m. Relays

60-163. Transistorized Phase Comparison Relaying Principles and Circuits. *C. G. Dewey, M. E. Hodges,* General Electric Company.

CP.* Transistorized Phase Comparison Relaying Application & Tests. *S. H. Horowitz,* American Electric Power Service Corporation; *A. J. McConnell,* General Electric Company; *H. T. Seeley,* General Electric Company.

CP.* The Use of Semiconductors in Control Circuits. *R. E. Dietrich,* Bonneville Power Administration.

9:00 a.m. Radiation Effects

CP.* Radiation Effects and Electronic Components. *E. R. Pfaff,* Admiral Corporation.

CP.* Calculation of Absorbed Dose from Electron Irradiation. *C.H. Cheek, V. J. Linnenbom,* U. S. Naval Research Laboratory.

CP60-89. Post Irradiation Thermal and Electrical Properties of Magnet Wire Insulation. *J. W. Kallander,* U. S. Naval Research Laboratory.

9:00 a.m. Approaches to the Solution of Computer Problems

CP60-128. Automation of Computer Panel Wiring. *G. W. Altman, L. A. DeCampo, C. R. Warburton,* International Business Machines Corporation.

CP60-129. The Magnetic Analog, with Spiral Search Coils. *A. D. Moore,* University of Michigan.

CP60-130. Universal Modulus (Matrix Logic VI). *E. J. Schubert,* Monitor Systems Inc. (formerly with Burroughs Corporation).

CP.* Automatic Multiprogram Operating System. *C. H. Gaudette, Y. C. Lo,* Minneapolis-Honeywell Regulator Company.

CP.* Automatic Program Checkout, A New Approach. *R. P. Sell,* Minneapolis-Honeywell Regulator Company.

2:00 p.m. Thermionic Energy Converters

CP.* Construction of a Thermionic Energy Converter. *F. H. Corregan, H. G. Hernqvist,* Radio Corporation of America Laboratories; *F. G. Block, G. Y. Eastman, J. R. Fendley, E. J. Hills,* Radio Corporation of America.

CP.* The Los Alamos Plasma Thermocouple *D. J. Roehling,* University of California.

CP.* State of the Art of the High-Vacuum Thermionic Converter. *E. A. Baum,* General Electric Company.

CP.* Recent Progress in the Development of Nuclear Powered Thermionic Converter Power Systems. *J. Barnard,* General Electric Company.

CP.* Effects of Anode Emission in Vacuum Thermionic Power Converters. *A. E. Dugan,* Lockheed Missiles and Space Division.

CP60-79. The Effect of Staging on the Performance of Thermionic Converters. *G. N. Hatsopoulos,* Massachusetts Institute of Technology.

CP.* Potentialities of Cascaded Thermionic—Solid-State Converters. *W. J. van der Grinten,* General Electric Company.

2:00 p.m. Chemical and Petroleum Industries

CP60-55. Power Distribution to Refinery Process Units. *W. H. Dickinson,* Esso Research & Engineering Company (Re-presented for discussion only).

CP.* Wire and Cable for Chemical Plants. *F. S. Deck,* E. I. DuPont de Nemours and Co., Inc.

CP60-56. The General-Purpose Analog Computer. *E. A. Clarke,* Humble Oil & Refining Company.

2:00 p.m. Special Instruments and Measurements

60-1. Bibliography on Ground Resistance and Potential Gradient Measurements. AIEE Subcommittee of Special Instruments and Auxiliary Apparatus Committee, J. C. Parker, chairman.

CP60-176. The Use of the Electrolytic Tank for Determining External Inductances of Enclosed Conductors. *L. L. Mankoff, R. H. Brealey, Jr.,* General Electric Company.

CP.* Instrument Standardization in an Industrial Laboratory. *E. E. Zimmerman,* Chrysler Corporation.

CP.* The Fundamental Properties of Matter as Related to Measurement and Control of Wire Tension. *E. J. Saxl,* Tensitron, Inc.

2:00 p.m. Electric Space Heating and Heat Pumps

CP.* A Statistical Method for Determining Heat Losses in Electrically Heated Residences. *E. E. Linden,* Narragansett Electric Company.

CP.* Heat Storage as Applied to Residential Heat Pumps. *J. A. Eibling,* Battelle Memorial Institute.

CP.* Economics of Heat Pumps. *M. Wilson*, Carrier Corporation.

CP.* Calculating the Electric Heating Load. *W. R. New*, Tennessee Valley Authority.

2:00 p.m. Communication Theory

2:00 p.m. Insulators and Radio Influence

CP60-191. Measuring the Lightning Strength of High-Voltage Insulators. *A. D. Lantz, Jr.*, Ohio Brass Company.

60-93. A Comparison of European and American Wet Flashover Test Methods. *B. E. Kingsbury*, General Electric Company.

60-90. The Electric Stress Grading of Insulator Strings and their Radio Influence Voltages. *A. S. Denholm*, National Research Council.

CP60-192. Radio Frequency Propagation and Attenuation on the American Electric Power Dequine-Olive 345-Kv Line. *L. O. Barthold, J. J. LaForest*, General Electric Company; *R. H. Schlomann*, American Gas & Electric Service Corporation; *F. J. Trebby*, Kaiser Aluminum & Chemical Corporation.

60-95. Radio Interference Studies for Extra-High-Voltage Lines in Ontario. *J. Reichman, J. R. Leslie*, Hydro-Electric Power Commission of Ontario.

2:00 p.m. Switchgear

60-209. The Effect of Current Chopping in Current Breakers on Networks and Transformers—I. Theoretical Considerations. *T. H. Lee*, General Electric Company.

CP60-207. The Effect of Current Chopping Circuit Breakers on Networks and Transformers — II. Experimental Techniques and Investigations. *A. N. Greenwood*, General Electric Company.

CP60-208. Physical Factors in Expulsion Type Fuse Cutout Design. *R. J. Bronikowski*, Line Material Industries.

CP60-107. Mechanical Loadings on Circuit Breaker Bushings. *E. F. Huston*, Ohio Brass Company; *E. B. Rietz*, I-T-E Circuit Breaker Company.

2:00 p.m. Relays

60-155. A New Approach to the Pilot Wire Protection of Transmission Lines Using Leased Pilot Wires Having Relatively Long Electrical Characteristics. *J. H. Neher*, Philadelphia Electric Company.

60-164. Subharmonic Ferro-Resonance in Coupling-Capacitor Potential-Device and Method of Prevention. *T. T. Norimatsu*, Electrotechnical Laboratory; *H. Uyeda*, Nissin Electric Company, Ltd.

60-26. Bibliography of Relay Literature 1957-58. AIEE Subcommittee on Bibliography of Relay Literature of the Relays Committee, R. W. Hittler, chairman.

2:00 p.m. Radiation Effects Symposium

CP.* Thermoelectric Power. *P. H. Klein*, General Electric Company.

CP.* Transmission of Electromagnet Waves through an Ionized Atmosphere. *W. T. Greenhow*, Chance Vought Aircraft Corporation.

2:00 p.m. Rotating Machinery

60-169. A Practical Commutator Primitive for Generalized Machine Theory. *T. H. Barton*, McGill University; *C. V. Jones*, Liverpool University.

CP.* Basis for Inductance Calculations in Commutation Design—II. *H. E. Koenig, H. K. Kesavan, J. D. Edick*, Michigan State University.

CP.* Digital Techniques in Commutation Design—III. *H. K. Kesavan, H. E. Koenig*, Michigan State University.

CP.* A New Criterion for Satisfactory Commutation—I. *H. K. Kesavan, H. E. Koenig*, Michigan State University

2:00 p.m. Symposium on Grounding for Safety

2:00 p.m. Man-Machine Integration and Complex Control Systems

CP.* Automatic Maintenance Operation in an Electronic Telephone Central Office. *W. Ulrich*, Bell Telephone Laboratories.

CP.* Use of an Electronic Data Processing System in Making Military Operational Decisions. *R. G. Pfefferkorn*, International Electric Corporation.

CP.* Experience in Using the Sage Computer for Sage System Operator Training and Analysis of Operator Performance. *J. L. Morey*, Systems Development Corporation.

2:00 p.m. Design Theory of Combinational Switching Circuits (Tutorial Session)

CP.* Introduction to Switching (Boolean) Algebra. *N. R. Scott*, University of Michigan.

CP.* Binary Numbers, Codes and Translators. *W. J. Cadden*, International Business Machines Corporation.

CP.* Formulation of Switching Problems. *J. P. Runyon*, Bell Telephone Laboratories.

CP.* Representation of Switching Functions. *E. J. Tanana*, Western Electric Company.

CP.* Minimization Theory. *E. J. McCluskey, Jr.*, Princeton University.

CP.* Design Using Computers. *T. C. Bartee*, Massachusetts Institute of Technology.

7:30 p.m. International Communications

7:30 p.m. Forum of Technical Committee Chairmen

Thursday, February 4

9:00 a.m. Modern Circuit Techniques I

CP.* Esaki Diode Characterization. *D. E. Thomas*, Bell Telephone Laboratories.

CP.* Tunnel Diode Circuit Aspects and Applications. *W. F. Chow, U. S. Davidsohn, Y. C. Hwang, C. S. Kim, G. B. Ober*, General Electric Company.

CP.* Ferroelectric Energy Converter Circuits. *S. R. Hoh*, International Telephone and Telegraph Laboratories.

CP.* High-Speed Silicon P-N-P-N Diodes. *A. N. Baker, J. M. Goldey, I. M. Mackintosh*, Bell Telephone Laboratories.

CP.* Cascaded Automatic Gain Control. *J. S. Brown*, General Electric Company.

9:00 a.m. Control Systems Components

CP.* Analog to Digital Devices. *W. Gains, P. P. Fischer.*

CP.* Variable Reactance and Linear Differential Transformer-Type Transducers. *C. W. Baird.*

CP.* A-C Servo Motors, Resolvers, etc. *T. N. Feng, E. Gamble.*

CP.* Gyros. *C. Ianoff.*

CP.* A Paper Covering the Objectives of Component System Performance Evaluation Subcommittee. *J. R. Shull.*

9:00 a.m. Automation Systems in Metal Industry

CP.* Advanced Electrical Systems for Application to Metal Industry Processes. *W. H. Dauberman*, Westinghouse Electric Corporation.

CP.* Automation for Sinter Plants. *R. L. Houlton, D. E. Hamilton*, General Electric Company.

CP.* Data Accumulation and Logging Systems for Stul Strip Processing Lines. *G. J. Hay*, Westinghouse Electric Corporation.

CP.* Servo Control for Synchronized Converters. *A. E. Lewis*. Clark Controller Company.

9:00 a.m. Production and Application of Light

60-24. Voltage-Temperature Life Testing of Fluorescent Ballast Insulation Systems. *C. A. Howlett*, General Electric Company (Deceased).

CP.* Acceptance and Use of Higher Lighting Levels. *G. J. Taylor*, Day-Brite Lighting Inc.

CP.* Integrated Lighting Air-Conditioning Systems. *W. S. Fisher*, General Electric Company.

9:00 a.m. Capabilities of the Telephone Network for Data Transmission

CP.* Evaluating the Telephone Message Plant for Data Transmission—Description of Testing Program. *A. A. Alexander*, American Telephone and Telegraph Company.

CP.* Basic Transmission Characteristics of the Telephone Network, Net Loss, Bandwidth, Delay, and Noise. *D. W. Nast*, Bell Telephone Laboratories.

CP60-99. Data-Phone-Customer Usage Results. *R. W. Ralston*, American Telephone & Telegraph Company.

CP.* A High-Speed (105,000 bit per second) Data-Transmission System. *R. H. Coe*, Pacific Telephone and Telegraph Company; *R. T. James*, American Telephone and Telegraph Company.

9:00 a.m. Wire Communications

CP.* E6 Voice Repeater—Background and Theory of Operation. *L. Hochgraf*, Bell Telephone Laboratories.

CP.* E6 Voice Repeater—Description and Testing. *J. O. Smethurst*, Bell Telephone Laboratories.

CP.* E6 Voice Repeater—Packaging Design. *L. Pedersen*, Bell Telephone Laboratories.

CP.* E6 Voice Repeater—Production Planning. *R. Mittermann*, Western Electric Company.

CP.* E6 Voice Repeater—Engineering and Installation. *E. J. Doyle, T. J. Talley, III*, American Telephone and Telegraph Company.

9:00 a.m. Power System Communications

9:00 a.m. Protective Devices

CP.* Application for Arresters for Lightning Protection of Multiline Substations. *J. M. Clayton, F. S. Young*, Westinghouse Electric Corporation.

CP.* Arrester Protection of High-Voltage Stations against Lightning. *G. D. Breuer, R. H. Hopkinson, I. B. Johnson, A. J. Schultz*, General Electric Company.

CP.* An Analysis of Arrester Operating Duty Using a Thermal Approach. *E. F. Reis, M. C. Galiyano*, Pennsylvania Power & Light Company; *J. Teno*, Lehigh University.

CP.* Radio Influence Voltage Values for Lightning Arresters. *H. R. Armstrong*, Detroit Edison Company.

CP.* Problems in Lightning Arrester Standardization. *W. F. Griffard*, Commonwealth Associates, Inc.

9:00 a.m. Power Generation Planning

CP.* An Approach to Peak Load Economics. *C. D. Galloway, L. K. Kirchmayer, W. D. Marsh, A. G. Mellor*, General Electric Company (Re-presented for discussion only).

60-156. Load and Capacity Models for Generation Planning by Simulation. *C. J. Baldwin, C. A. DeSalvo*, Westing-

house Electric Corporation; *C. H. Hoffman, E. C. Plant,* Public Service Electric and Gas Company.

CP.* The Use of Simulated Reserve Margins to Determine Generator Installation Dates. *C. J. Baldwin, D. P. Gaver,* Westinghouse Electric Corporation; *C. H. Hoffman, J. A. Rose,* Public Service Electric and Gas Company.

CP.* Announcement of Future Roundtable Discussion on Power Station Automation. *D. M. Sauter,* Westinghouse Electric Corporation.

9:00 a.m. Substations and Transformers

CP60-42. 400-Mva Bulk Power Substation in Metropolitan Area. *C. M. Short, H. L. Holland,* City of Los Angeles Department of Water & Power.

60-175. Some Characteristics of Audible Noise of Power Transformers and their Relationship to Audibility Criteria and Noise Ordinances. *M. W. Schulz, Jr., R. J. Ringlee,* General Electric Company.

CP.* Sound Barrier Walls for Transformers. Working Group on Technical Investigations of the Subcommittee on Audible Sound of the AIEE Transformer Committee. M. W. Schulz, Jr., chairman.

CP.* Mobile Test Unit Brings Factory Testing to Power Transformer Repair Shop. *E. A. Thompson, W. H. Schneider,* Westinghouse Electric Corporation.

9:00 a.m. Basic Sciences

CP60-193. Generalized Recurrence Relations in the Analysis of Physical Nonlinear Systems. *A. A. Wolf,* Stromberg-Carlson Company.

CP60-194. Electromagnetic Induction Damping of Vibratory Motion. *L. B. Cherry,* Lamar State College of Technology.

60-196. Voltage Regulation in Modern Aircraft Electric Power Systems. *A. Krauzs,* Space Technology Laboratories, Inc.; *H. A. Kahle,* Jack & Heintz, Inc.

CP60-195. A Transistorized D-C Voltage Regulator for Direct Replacement of Carbon-Pile Regulators. *P. D. Corey, W. O. Hansen,* General Electric Company.

CP.* Determination of the Transient Response of the Heaviside—Bessel Non-Uniform Transmission Line. *D. T. Frankos, T. J. Higgins.*

9:00 a.m. Semiconductor Rectifying Devices and Applications—I

CP60-67. A Silicon Controlled Rectifier—Its Characteristics and Ratings—II. *D. K. Bisson, R. F. Dyer,* General Electric Company.

CP.* 100-Kw Transistors. *J. Philips, E. W. Torok,* Westinghouse Electric Corporation.

CP.* Switching Characteristics of Silicon Power Controlled Rectifiers—I, Turn-on Action. *I. Somos,* General Electric Company.

CP.* A Thermal Compression—Bonded Low Temperature—Coefficient Voltage Regulating Diode. *J. R. Singleton, H. D. Sloan,* Bell Telephone Laboratories, Inc.

60-19. An Investigation of the Dynamic Switching Properties of 4-Layer Diodes. *G. E. McDuffie, Jr., W. L. Chadwell,* Catholic University of America (Re-presented for discussion only).

9:00 a.m. Application of Computers in Manufacturing

CP.* Integrated Systems Planning. *B. Grad,* General Electric Company.

CP.* Production Line Balancing. *A. L. Paul,* Westinghouse Electric Corporation.

CP60-131. An Experiment in Simulation of Factory Operation on a Digital Computer. *R. S. Clement,* General Electric Company.

CP60-132. Complete Manufacturing Information Produced by Computer for Large A-C Motor Coils. *T. N. Kyriazi, R. C. Fuller,* Westinghouse Electric Corporation.

9:00 a.m. Panel Discussion on "New Challenges to Electrical Engineers From Medical and Biological Problems"

Opening Address: J. H. Foote, president, AIEE.
Moderator: S. Talbot, Johns Hopkins Hospital.

CP.* Radiology: G. Henny, Temple University.

CP.* Biology: O. Schmitt, University of Minnesota.

CP.* Space Medicine: A. Hetherington, Air Research and Development Command.

2:00 p.m. Modern Circuit Techniques II

CP.* Solid-State Switching Logic for Airborne Control Systems. *K. H. Doerenkamp, R. W. Churchill,* Minneapolis-Honeywell Regulator Company.

CP.* A Switching Amplifier for a Space Vehicle Stable Platform Control System. *J. McHugh,* General Electric Company.

CP.* Characteristics of Wide-Band Direct Coupled Amplifiers. *J. Varga,* General Electric Company.

CP.* Transistor Morse to Teleprinter Code Converter. *J. F. Cunniff, C. E. Theall, Jr.,* C.G.S. Labs., Inc.

CP.* The Design of the Generator Voltage Regulator. *B. M. Van Emden,* Hydro-Aire Corporation.

2:00 p.m. Mathematicians Look at Nonlinear Control Systems

CP60-109. Discrete Models for Nonlinear Systems. *W. Kaplan,* University of Michigan.

CP.* Problems of Asymptotic Behavior and Stability. *L. Cesari,* Purdue University & RIAS.

CP60-110. Recent Advances in the Analysis and Synthesis of Nonlinear Systems. *A. A Wolf,* Stromberg-Carlson Company.

60-111. On A Systematic Approximation to the Partition Method for Analysis of A Class of Nonlinear Systems. *Y. H. Ku, J. H. Dietz,* University of Pennsylvania; *A. A. Wolf,* Stromberg-Carlson Company.

CP * Minimal Time Problems and Maximum Principle. *L. A. Zadeh,* University of California.

CP.* Bibliography on Recent Contributions in the Nonlinear Theory Area. *T. H. Higgins,* University of Wisconsin.

2:00 p.m. Electric Systems for Metal Industry

CP.* The Rectifier Power Supply on the Lukens Steel Reversing Plate Mill. *R. A. Hamilton,* General Electric Company.

CP.* Rectifier Power Supplies for Auxiliary Drives. *S. J. Roumanis,* General Electric Company.

CP.* Application of Rotating Magnetic Stirrers to Electric Arc Furnaces. *R. D. Thomas,* Westinghouse Electric Corporation.

2:00 p.m. Analog and Digital Data Handling

CP.* A Precision Voltage Reference for Industrial Recorders. *P. B. Robinson,* General Electric Company.

CP.* Design and Performance Characteristics of a High-Speed Wide Chart Recorder. *J. C. Garrigus,* Bristol Company.

CP.* A Power Line Transient Recorder. *G. H. Hoshall,* Davies Laboratories.

60-104. A Solid-State Digital Computing System for Electric Load Monitoring. *R. J. Thomas,* Union Carbide Nuclear Company; *J. O. Gustafson,* Bailey Meter Company; *G. E. Foster, Lundell Thomas,* Union Carbide Nucleonics.

60-158. The Combi-System—A Proposal for New Concepts in Digital Data Processing. *H. Schwab,* Consolidated Electrodynamics.

2:00 p.m. Telegraph Systems

CP.* Freight Car Report Sorting System. *C. R. Fisher,* Stromberg-Carlson Company.

60-183. A Step-Driven Digital Magnetic Recorder. *J. G. Hansen,* Stromberg-Carlson Company.

CP.* The 82B1 Military Teletypewriter Message Switching System. *W. M. Bacon, G. A. Locke,* Bell Telephone Laboratories, Inc.

CP.* Recent Advances in Printing Telegraph Apparatus. *W. Y. Lang,* Bell Telephone Laboratories, Inc.

CP.* Advancements in the Facsimile Art During 1959. *W. A. Bliss,* Radio Corporation of America Laboratories.

2:00 p.m. Wire Communications

CP.* A Pole Mounted Negative Impedance Repeater. *H. W. Clark,* Stromberg-Carlson Company.

CP.* Application of the E3 Repeater on Nonloaded Cable. *J. W. Joyner,* Southern Bell Telephone and Telegraph Company.

CP60-43. The REA-1 Transposition System. *A. G. Chapman, J. M. Flanigan,* Rural Electrification Administration; *J. V. Buscemi,* Anaconda Wire & Cable Company.

CP.* Wire Line Communications on the Union Pacific Railroad. *C. O. Jett,* Union Pacific Railroad.

60-44. An All-Transistorized Trunk Carrier System. *F. H. Gardner,* Stromberg-Carlson Company.

2:00 p.m. Transformers

60-80. Dielectric Tests on Transformers as Influenced by Further BIL Reductions. *J. R. Meador, N. E. Dillow,* General Electric Company.

CP.* Some Aspects of Ground Current Measurements during Transformer Impulse Tests. *L. C. Aicher,* Allis-Chalmers Manufacturing Company.

60-182. Pseudo-Final Voltage Distribution in Impulsed Coils and Windings. *P. A. Abetti,* General Electric Company.

CP.* Front-of-Wave Air Gap Data Suggests Refinement in New Standard. *C. A. Long, C. L. Moore,* Westinghouse Electric Corporation.

2:00 p.m. Power System Economic Dispatch

CP60-179. Power System Economic Load Allocation Using a New Equation for Transmission Losses. *M. J. Fisher,* Washington University.

60-82. A New Method of Making Transmission Loss Formulas by Means of Eigenvalues and Modal Matrices. *E. E. George,* Ebasco Services Inc.

CP.* Direct Calculation of Transmission Loss Formula—I. *L. K. Kirchmayer, H. H. Happ,* General Electric Company; *G. W. Stagg, J. F. Hohenstein,* American Electric Power Service Corporation.

CP.* Hydro-Thermal Economic Scheduling—Computational Experience with Co-ordination Equations. *P. L. Dandeno,* Hydro-Electric Power Commission of Ontario.

CP.* Hydro-Thermal Economic Scheduling—Solution by Incremental Dynamic Programming. *B. Bernholz, L. J. Graham,* Hydro-Electric Power Commission of Ontario.

2:00 p.m. Power Generation and New Energy Sources

CP60-108. A New Minimum Excitation Limiter for Electric Utility Generator Regulating Systems. *P. O. Bobo, N.*

Kormanik, H. A. Steinbruegge, Westinghouse Electric Corporation.

CP60-157. A Simplified Method for Determining a Transfer Scheme on Generating Station Auxiliary Buses. *J. L. Barker, S. M. Hussey, S. J. Sweeney*, Boston Edison Company.

CP.* Thermoelectric and Mechanical Conversion of Solar Power. *R. C. Schlichtig, A. J. Morris*, Boeing Airplane Company.

CP.* Recent History of Thermoelectric Development. *S. J. Angello*, Westinghouse Electric Corporation.

2:00 p.m. Symposium on Extra-High-Voltage Substations

2:00 p.m. Thermoelectricity

CP.* Theoretical Bounds on the Thermoelectric Figure of Merit. *F. J. Donahoe*, Franklin Institute Laboratories.

CP60-173. Thermoelectric Concepts for Engineers. *A. G. Milnes, N. Alfonso*, Carnegie Institute of Technology.

60-18. The Effect of Source and Sink Thermal Resistance on Thermoelectric Generator Performance. *P. E. Gray*, Massachusetts Institute of Technology.

CP60-174. Transient Response and Ripple Effects in Thermoelectric Cooling Cells. *N. Alfonso, A. G. Milnes*, Carnegie Institute of Technology.

2:00 p.m. Radiation Effects Roundtable Discussion

2:00 p.m. Semiconductor Rectifying Devices and Applications—II

CP60-68. Transient Thermal Impedance of Semiconductor Devices. *E. J. Diebold*, Perkin Engineering Corporation; *W. Luft*, International Rectifier Corporation.

CP60-69. Power Semiconductor Ratings under Transient and Intermittent Loads. *F. W. Gutzwiller, T. P. Sylvan*, General Electric Company.

CP60-70. Problems Encountered in Applying the Silicon Controlled Rectifier To Control Tungsten Lamp Loads. *C. S. Daugherty*, Vickers Inc.

CP60-71. Trinistor Triode Power Inversion. *F. J. Hierholzer*, Westinghouse Electric Corporation.

2:00 p.m. Electrical Techniques in Medicine and Biology

CP.* Thermoelectrical Applications in Bio-Medical Studies. *J. D. Mees*, Westinghouse Electric Corporation.

CP.* An X-Ray Tube with Grid Control for Exposures in Cineradiography. *T. H. Rogers*, Machlett Laboratories.

CP.* Microliter Oxygen Detector in Medical Research. *V. W. Bolie*, Iowa State University.

CP60-100. Instrumentation for the Diagnosis of Coronary-Artery Disease. *D. E. Moyer, G. D. Talbott*, Dayton, Ohio.

CP.* New Developments in Heart-Lung Bypass Systems. *G. C. Riggle, J. M. F. DeBroske*; National Institutes of Health.

CP.* Use of a Low-Power Nuclear Reactor in Biology and Medicine. *A. J. Blotcky, A. L. Dunn, R. E. Ogborn*, Veterans Administration Hospital.

CP60-101. Experiments with Air Ions on the Trachea. *J. C. Beckett*, Wesix Electric Heater Company; *A. P. Krueger*, University of California.

Friday, February 5

9:00 a.m. Feedback Control Systems

CP60-115. Input - Output Cross - Correlation Functions for Some Memory-Type Nonlinear Systems with Gaussian Inputs. *H. R. Leland*, Cornell Aeronautical Laboratory, Inc., of Cornell University.

CP60-116. Nonlinear Compensator for a Piecewise Linear Second Order. *M. Athanassiades, O. J. M. Smith*, University of California.

CP60-117. Stability Analysis of Dual-Mode Servomechanisms. *J. E. Gibson, E. S. McVey*, Purdue University.

CP60-118. Instrument Servomechanisms with Backlash, Coulomb Friction and Stiction. *M. P. Pastel, G. J. Thaler*, U.S. Naval Postgraduate School.

9:00 am. Industrial Control

9:00 a.m. Data Communications over Wire Systems

60-27 The Effect of Delay Distortion on Data Transmission. *P. Mertz*, Rand Corporation.

CP.* Layout and Adjustment of a Nationwide Facsimile Network for Weather Map Service.

60-45. A Delay Distortion Simulation Set. *F. C. Dunbar*, Bell Telephone Laboratories, Inc.

CP60-46. A Test Set for Measurement of Envelope Delay Distortion at Audio Frequencies with 1 μsec Precision. *W. A. Codd*, Stromberg-Carlson Company.

CP.* A Survey of Cable Characteristics for Data Communication. *F. B. Wood*, International Business Machines Corporation.

9:00 a.m. Radio Communication Systems

CP60-159. A New Control Terminal for Mobile Telephone Service. *L. E. Getgen, G. McGibbon*, Lenkurt Electric Company, Inc.

CP60-160. Automation Applied to Mobile Radio Transmission Surveys. *H. E. Strong, V. Feldkircher*, The Ohio Bell Telephone Company.

CP60-161. Intermodulation Effects in FM and PM Systems. *B. E. Love*, American Telephone & Telegraph Company.

CP.* Service Area of an Airborne Television Station. *M. T. Decker*, National Bureau of Standards.

9:00 a.m. Transformers

CP.* A Report on the Proposed AIEE Test Procedure for Evaluation of Insulation Systems for Specialty Transformers. *P. A. Vance*, General Electric Company.

CP.* Test Equipment Used to Evaluate Specialty Transformer Insulation Systems in Accordance with the Proposed AIEE Test Procedure. *E. W. Lindsay*, Westinghouse Electric Corporation.

CP.* Evaluating a Specialty Transformer Insulation System by the Proposed AIEE Test Procedure. *D. S. Stephens, E. W. Lindsay*, Westinghouse Electric Corporation.

CP.* Specialty Transformer Life Test Procedures in Selecting Impregnating Varnishes. *D. H. Briggeman, G. I. Duncan*, General Electric Company.

9:00 a.m. Power Generating Capacity Problems

CP.* Bibliography of Load and Frequency Control Literature 1922-1957. *J. Preminger*, Israel Institute of Technology.

CP60-37. Application of Probability Methods to Generating Capacity Problems. AIEE Probability Applications Working Group: Presentation of Report and Panel Discussion by: H. A. Adler, A. K. Falk, C. D. Galloway, C. Kist, E. S. Loane, and L. K. Kirchmayer, chairman.

9:00 a.m. Insulated Conductors

60-94. Mathematical Solution to the Problem of the Control of the Thermal Environment of Buried Cables. *J. V. Schmill*, The Mexican Light and Power Company, Ltd.

60-141. Characteristics of Power Cable Shielding. *T. N. Mitropoulos, R. J. Fogel, C. J. Tang*, Simplex Wire & Cable Company.

CP.* A New High Voltage Capacitor-Graded Pothead. *E. F. Huston*, Ohio Brass Company.

9:00 a.m. Corona Effects

CP60-97. A Capacitance Bridge Method for Measuring Integrated Corona Charge Transfer and Power Loss per Cycle. *T. W. Dakin, P. J. Malinaric*, Westinghouse Electric Corporation.

69-15. The Measurement and Influence of Surface Charges on the Inception Voltage Between Dielectric and Metal Dielectric Surfaces. *S. I. Reynolds*, General Electric Company.

CP.* The Study of Discharges in Dielectric Voids by Photomultiplier Methods. *N. M. Bashara*, University of Nebraska.

CP.* Ionization and Electron Attachment Coefficients in Alkyl Chlorides. *J. C. Devins, O. H. LeBlanc*, General Electric Company.

9:00 a.m. Rotating Machinery

60-98. Calculation of Stray Load Losses in D-C Machinery. *E. Erdelyi*, University of Delaware.

CP60-170. Armature Tooth Pulsations Eddy Current. *M. J. Pasculle*, Westinghouse Electric Corporation.

60-154. The Effect of Rectifier Power Supply on Large D-C Motors. *R. M. Dunaiski*, General Electric Company.

CP.* On the Simplification of Introduction of the Signal-Flow-Graph in Electrical Machine Analysis. *P. E. Magyar, M. Sobral, Jr., A. A. Leirner, P. P. G Gonzaga*, Instituto Technológico de Aeronáutica.

CP60-172. A Practical Method for Obtaining the Over-all External Characteristics of an Unstable D-C Shunt Self-Excited Generator. *P. E. Magyar, A. A Leirner*, Instituto Technológico de Aeronáutica.

9:00 a.m. Education

CP.* The Public Schools in Relation to Electrical Engineering Education. *T. M. Linville*, General Electric Company.

CP.* The Technical Institutes Part in Electrical Engineering Education. *S Linke*, Cornell University.

CP.* Electrical Engineering Education in Industry. *L. N. Stone*, Oregon State College.

CP.* Electrical Engineering Education through Membership in AIEE. *C. R. Vail*, Duke University.

9:00 a.m. Molecular Electronics I

CP.* Molectronics. *H. W. Henkels*, Westinghouse Electric Corporation.

CP.* A Categorization of Molecular Engineering. *J. W. Brouillette, S. K Ghandi, A. Lesk*, General Electric Company.

CP.* Phenomena of Interest to Molecular Electronics. *R. D. Larson, J. M. Blasingame*, Wright Air Development Center.

CP.* *R. H. Rediker*, Lincoln Laboratories

CP.* *H. R. Owens*, Texas Instrument, Inc.

9:00 a.m. Basic Sciences

60-197. A Method for the Design of Holding Electromagnets. *J. T. Ludwig*. Minneapolis-Honeywell Regulator Company.

60-198. Inductors Biased with Permanent Magnets—Part I. *J. T. Ludwig*, Minneapolis-Honeywell Regulator Company.

60-199. Inductors Biased with Permanent Magnets—Part II. *J. T. Ludwig*, Minneapolis-Honeywell Regulator Company.

CP.* The Existence of an Electric Analog of a Magnetic Circuit by the Laws Defining Magnetostatics. *E. C. Koenig*.

CP60-200. The Determination of the Hysteresis Curve for Thick Tape Cores. *P. Dentella*, Fivre Company; *E. DellaTorre*, Rutgers University.

CP.* A Correction of the Present Design Method for Permanent Magnets Exposed to External Fields. *M. Schindler*, Radio Corporation of America.

CP60-201. An Analysis of a Polarized Electromagnetic Drive System and of Vibrator Systems. *R. S. Nunn*, Hampshire Eng.

2:00 p.m. Feedback Control Systems

2:00 p.m. Industrial Control

2:00 p.m. Telemetering

2:00 p.m. Radio Communication Systems

60-54. Radio Frequency Interference Considerations in the TD-2 Radio Relay System. *H. E. Curtis*, Bell Telephone Laboratories, Inc.

CP.* Radio Communication in Aviation. *P. Caporale*, Federal Aviation Agency.

CP60-162. A Format for a Fundamental Plan for the Improvement of Telecommunication Facilities in Underdeveloped Countries. *C. A. Parry*, Page Communications Engineers, Inc.

CP.* RF Transmission Line Engineering. *R. F. Lewis*, Prodelin, Inc.

2:00 p.m. Television—Color and Monochrome

CP60-59. Redstone Arsenal Closed Circuit Educational TV System. *J. P. Argo, I. N. Howell*, Southern Bell Telephone & Telegraph Company.

CP.* Aspects of the Land Color System (Including Demonstration) *W. Hughes*, Iowa State College.

CP.* A Field Sequential Color Mobile Unit to Work with Ediphor. *L. Tyrrell*, Teletone.

CP60-60. Automatic Logging of AM, FM, and TV Transmitting Station Parameters. *G. Ehrenberg*, Minneapolis-Honeywell Regulator Company.

60-11. An Omnidirectional Circular Antenna Array Excited Parasitically by a Central Driven Element. *H. P. Neff, J. D. Tillman*, University of Tennessee.

60-66. Dial Selected Industrial Television for Ticket Reservation Facilities. *J. W. Alinsky*, Dage Television Division, Thompson Products, Inc. (Re-presented for discussion only).

2:00 p.m. Transformers

CP.* Short-Time Overcurrent Ratings of CT's and CB's Proposed Co-ordination Standards. *G. S. Duffus*, Canadian Westinghouse Company, Ltd.

60-58. Permalex—A New Insulation System. *M. F. Beavers, E. L. Raab, J. C. Leslie*, General Electric Company.

60-81. Oil Preservation Systems, Factors Affecting Ionization in Large Transformers. *A. T. Chadwick, D. H. Ryder, A. E. Brierley*, English Electric Company, Ltd.

CP.* Studies of Insulating Oil in New and Used Transformer. *T. K. Sloat*, Westinghouse Electric Corporation; *V. A. Banevicius*, Cleveland Electric Illuminating Company.

2:00 p.m. Power System Short-Circuit Current Calculation

CP.* Digital Computer Study of the Resynchronizing of a Turbo-Alternator. *R. N. Sudan*, Cornell University.

CP60-180. Digital Calculation of Line-to-Ground Short Circuits by Matrix Method. *A. H. El-Abiad*, Purdue University.

CP60-181. Digital Calculation of 3-Phase Short-Circuits by Matrix Method. *H. E. Brown, C. E. Person*, Commonwealth Edison Company; *L. K. Kirchmayer*, General Electric Company; *G. W. Stagg*, American Electric Power Service Corporation.

CP60-182. Digital Calculations of Single-Phase-to-Ground Faults. *H. E. Brown, C. E. Person*, Commonwealth Edison Company.

2:00 p.m. Insulated Conductors

59-892. The Texada Island Submarine Cable Crossing. *P. J. Croft*, British Columbia Power Commission (formerly with Canada Wire & Cable Company).

60-13. Gas-Filled Cavities in Solid-Type Cables. *N. Klein*, Israel Institute of Technology.

CP.* Correlation between Impregnant Stability under Vacuum Discharge and Life of Solid-Type Oil-Impregnated Paper Cable on Accelerated High-Voltage Load Cycle Test. *A. O. McKean, E. J. Merrell*, Phelps Dodge Copper Products Company.

CP.* Improving Building Wire Performance. *R. H. Lee*, E. I. DuPont de Nemours & Co., Inc.

2:00 p.m. Basic Sciences

CP60-202. The Synthesis of Linear Filters with Real or Imaginary Transfer Functions. *E. G. Gilbert, J. Otterman*, University of Michigan.

CP.* Automatic Plotting of Characteristic Curves and Analog Solution of Algebraic Equations. *D. Mitrovic*, University of Belgrade.

60-203. Difference Equations and their Applications. *L. A. Pipes*, University of California.

60-31. Generalized Brillouin Flow. *G. Kent*, Syracuse University.

CP60-204. Conformal Transformations in Analog Simulations of Non-Saplacian Fields. *J. R. Allder*, Space Technology Laboratories, Inc.; *W. J. Karplus*, University of California; *R. N. Bryan*, Pacific Semiconductors Inc.

2:00 p.m. Radiation Technology

2:00 p.m. Molecular Electronics II

CP.* Some New Examples of Molecular Engineering. *R. W. Aldrich, N. Holonyak, Jr., I. A. Lesk*, General Electric Corporation.

CP.* Theory and Applications of a Monolithic Null Device. *W. Kaufman*, Westinghouse Electric Corporation.

CP.* Microminiature Full Adder. *E. Keonjiam*, American Bosch Arma Corporation.

CP.* Microelectronics—A Circuit System Employing Microminiaturing Components. *E. Steele, W. B. Warren, R. A. Dgudmendsen*, Hughes Products.

6th Reliability Symposium Will Be Held January 11-13, 1960

THE 6TH NATIONAL Symposium on Reliability and Quality Control will be held January 11-13, 1960, at the Statler-Hilton Hotel in Washington, D. C. The symposium is sponsored jointly by the AIEE, the American Society for Quality Control (ASQC), the Institute of Radio Engineers (IRE), and the Electronic Industries Association.

This year's program will attempt to review most of the aspects of reliability from simple fundamentals to advanced concepts. Parallel sessions have been formed in order to meet the probable needs of various types of attendees.

The theme of this year's symposium is the same as it has been for several years: "A Report to the Nation on the State-of-the-Art in Reliability."

Speakers, panel discussions, a banquet at which Vice-Admiral J. T. Hayward will talk, and a copy of each paper presented will be among the features of the symposium.

A special Ladies Day Program has been planned for the wives of those who attend the technical sessions.

The tentative program follows:

Monday, January 11

8:00 a.m. Registration

9:00 a.m. Session

Keynote Address: Reliability–Responsibility. J. K. Sprague, president, Sprague Electric Company.

10:00 a.m. Morning Session

Military Requirements and Specifications

Moderator: J. Allen, Space Technology Laboratories, Inc.

Reliability in Contracts. *J. L. Burnside*, Lockheed Aircraft Corporation.

Improved Component Specifications. *R. E. Moe*, General Electric Company.

New Quality Assurance Techniques in Specifications. *H. G. Romig*, Hoffman Electronics Corporation.

New Production Techniques

Moderator: A. W. Rogers, U. S. Army Signal Research & Development Laboratory

New Production Techniques on Filters and Capacitors. *S. Sonobe*, Nippon Electric Company, Ltd.

Audio-Visual Aids to Human Reliability. *D. A. Hill*, Hughes Aircraft Company.

Decentralized Reliability Education. *J. M. Wuerth*, North American Aviation, Inc.

2:00 p.m. Afternoon Sessions

New Mathematical Techniques

Moderator: G. Levenbach, Bell Telephone Laboratories.

Random Balance Designs for Reliability. *G. H. Sandler*, Sylvania Electric Products, Inc.

Sequential Qualification: A Reliability Countdown. *D. R. Howes*, Army Chemical Center.

Analog Computers for Statistical Procedures. *M. H. Norton*, Booz-Allen Applied Research, Inc.

Accelerated Testing as a Problem of Modeling. *R. E. Thomas*, Battelle Memorial Institute.

Cost Considerations

Moderator: Rear Admiral R. Mandelkorn (U. S. Navy, retired), Philco Division, Lansdale Tube Company

A Reliability Economic Decision Method. *H. W. Price*, Diamond Ordnance Fuze Laboratory.

The Cost of Reliability vs. Maintenance Cost. Lt. Col. *W. F. Stevens*, Wright Air Development Center.

Rework Costs Related to Reliability Requirements. *W. R. Kuzmin*, Packard Bell Electronics.

An Information Theory Approach to Diagnosis. *R. A. Johnson*, Syracuse University.

5:00 p.m. Joint Husband and Wife Tea and Cocktail Party

7:30 p.m. Round Table Discussion

Moderator: J. M. Bridges, director, Office of Electronics, Office of the Director of Defense Research & Engineering

Advisory Members Participating

Tuesday, January 12

8:00 a.m. Registration

9:00 a.m. Morning Sessions

Training

Moderator: R. G. Fitzgibbons, Raytheon Company

Mathematics of Reliability. *J. M. Weisen*, Sandia Corporation.

Circuit Design Concepts for High Reliability. *F. E. Dreste*, Motorola, Inc.

Prediction of Reliability. *J. Conners*, Hughes Aircraft Company.

Design Review. *G. J. Armbruster*, Radio Corporation of America.

Failure Modes

Moderator: G. Neuschaefer, New York Naval Material Laboratory

Resistor Reliability-Capability Analysis. *B. R. Schwartz*, Radio Corporation of America.

Failure Modes in Electronic Components. *M. L. Granberg*, Sperry Rand Corporation.

Modes of Failure of Component Parts. *C. D. Jeffcoat*, Westinghouse Electric Corporation.

Part Improvement in Missile Guidance Applications. *J. Hepp*, General Motors Corporation.

Advanced Mathematical Theory

Moderator: Miss *G. M. Cox*, Research Triangle Institute

Negative Moments and the Evaluation of Reliability. *W. Mendenhall*, Bucknell University.

Multifactor Experiments in Life Testing. *M. Zelen*, National Bureau of Standards.

A Summary of Some New Techniques on Failure Analysis. *J. K. Kao*, Cornell University.

Estimation of Reliability from Incomplete Data. *G. R. Herd*, Booz-Allen Applied Research, Inc.

2:00 p.m. Afternoon Sessions

Training

Moderator: R. G. Fitzgibbons, Raytheon Company

Reliability Testing. *J. H. Hershey*, Bell Telephone Laboratories.

Failure Reporting. *E. Gould*, Hughes Aircraft Company.

Manufacturing Aspects of Reliability. *T. Wos*, Westinghouse Electric Corporation.

Field Reliability. *J. C. Burns*, ARINC Research Corporation.

Reliability Prediction

Moderator: J. A. Connors, Hughes Aircraft Company

Correlation of Laboratory and Field Reliability. *C. M. Bird*, International Business Machines Corporation.

Reliability Prediction—A Proven Method. *W. T. Wier*, General Electric Company.

The Practicality of Predicting Reliability Numbers. *W. E. Boyes*, Sandia Corporation.

Prediction of Mean-Times between Failure Bounds in Early Design. *R. Tiger*, United Aircraft Corporation.

Information Exchange Panel

Moderator: R. H. DeWitt, Office of Electronics, Office of the Director of Defense Research and Engineering

The Tri-Service and NOL Program. *M. Barbe*, Space Technology Laboratories, Inc.

Battelle Memorial Institute Data Pool. *C. R. Deeter*, Battelle Memorial Institute.

DOD Ad Hoc Committee on Component Reliability. *J. M. Glass*, Hughes Aircraft Company.

Inland Testing HELPER Program. *L. L. Schneider*, Inland Testing Laboratories.

Information Exchange Mechanics. *R. M. Jacobs*, Sylvania Electric Products, Inc.

Product Standardization and Technical Data Exchange. *E. F. Howrey*, attorney and partner with law firm of Howrey and Simon.

6:30 p.m. Banquet

Research and Development Aspects of Reliability. Vice-Admiral J. T. Hayward, U. S. Navy, assistant chief of naval operations (research and development).

National Reliability Award presented by C. M. Ryerson.

IRE—Professional Group on Reliability and Quality Control Award presented by P. K. McElroy, group chairman.

Wednesday, January 13

8:00 a.m. Registration

9:00 a.m. Morning Sessions

New Maintainability Techniques

Moderator: Gen. F. L. Ankenbrandt (U. S. Army, retired), Radio Corporation of America.

Maintenance Planning during Equipment Development. *R. I. Moeller*, International Business Machines Corporation.

Maintainability Study on Shipboard Electronics. *J. Schechtel*, Federal Electric Corporation.

Practical Maintainability Numerics. *M. P. Feyerherm*, Radio Corporation of America.

Rome Air Development Center Maintainability Program. *M. P. Forte*.

Life Tests

Moderator: W. Sumerlin, Philco Corporation.

Life Test Acceptance Plans. *B. Epstein*, Stanford University.

High Temperature Burn-In for Silicon Diodes. *D. Cowan*, Continental Device Corporation.

The Selection of Components for Test Purposes. *W. G. Madow*, Stanford Research Institute.

Surface Barrier Transistor Life Characteristics. *J. E. Drennan*, Battelle Memorial Institute.

2:00 p.m. Sessions

System Aspects

Moderator: P. S. Darnell, Bell Telephone Laboratories.

Design Reliability Analysis—A Proven Technique. *H. Wuerffel*, Radio Corporation of America.

Some Effects of Redundance on System Reliability. *H. S. Balaban*, ARINC Research Corporation.

Reliability, the Engineer, and the Mathematician. *G. W. Holtzman, W. E. Marshall*, Minneapolis-Honeywell Regulator Company.

Reliability Measurement Applicable to Vigilante. *W. M. Roberts*, U. S. Army Ordnance & Proof Services.

Programs and Management

Moderator: Col. R. O. Mitterling, headquarters, Air Material Command.

A Field Reliability Data Program. *J. R. Holmes*, International Business Machines Corporation.

Designing in the Dark. *J. M. Farrier*, ARINC Research Corporation.

Small Samples Are Significant. *S. J. Wilson*, The Martin Company.

Supplier Reliability Assurance Program. *M. H. Saltz*, Hughes Aircraft Company.

Standby papers to be published in the *Transactions* include the following:

Automatic Fault Location Using Building Block Logic. *D. H. Breslow*, Raytheon Company.

Maintainability Improves Reliability. *J. A. Csepely*, Westinghouse Electric Corporation.

Surveillance Testing of Purchased Parts. *D. C. Fleming*, AC Spark Plug Division.

Reliability of Some 2-Unit Redundant Systems. *J. Hosford*, Philco Corporation.

Reliability—Where To Begin. *R. M. Jacobs*, Sylvania Electric Products, Inc.

Good Specifications—Key to Reliability. *R. E. Jones*, Bendix Aviation Corporation.

Effect of Preventive Maintenance on Reliability. *J. F. Kalbach*, Burroughs Corporation.

Prediction of Reliability of Mechanical Devices. *I. Kirkpatrick*, RCA Victor Division.

Electronic Parts Failure—Upper Critical Limits. *E. P. O'Connell*, Federal Electric Corporation.

Failure Categories of Guided Missiles. *E. G. Pieruschka*, Lockheed Aircraft Corporation.

Early Indications of Failures in Semiconductor Devices. *E. L. Silfen*, Hughes Aircraft Company.

Indirect Process Quality Control. *F. G. Spadaro*, Rocketdyne, NAA.

Statistical Aspects of System Analysis. *M. Stevens*, General Electric Company.

An Integrated Program for Reliability. *G. E. Unruh*, Cornell Design Company.

The cost of registration, including the price of the banquet and *Transactions*, is $20 in advance for members of AIEE, IRE, and ASQC, or $24 at the door. All others will be charged $22 in advance and $24 at the door.

Extra copies of *Transactions* may be obtained for $5 at the symposium or from IRE headquarters, 1 E. 79th St., New York 21, N. Y. Extra banquet tickets will cost $10 at the registration desk.

The award for the best technical paper delivered at this symposium will be presented at the 7th National Symposium on Reliability and Quality Control. Nominations will be accepted until May 31, 1960, by C. M. Ryerson, Radio Corporation of America, Building 10-2, Camden, N. J. The nominating ballots box will be located opposite the registration desk.

The Ladies' Program will be directed by Beatrice S. Orleans, chairlady, and Selma A. Koury, vice-chairlady. Complete advance registration will be $8. Partial or door registration also will be accepted.

Monday, January 11, has been set aside by the ladies for making new friends and informally seeing the town. The program will open with a long coffee period beginning at 9:00 a.m. Additional events have been planned for Tuesday and Wednesday.

SUPPORT THE NEW UNITED ENGINEERING CENTER

W. A. Del Mar Is Honored by Friends at Testimonial Dinner

A TESTIMONIAL DINNER was given to W. A. Del Mar by friends of long standing in the cable industry. Mr. Del Mar is the first recipient of the William Martin Habirshaw Award for meritorious achievement in electrical transmission and distribution. The dinner was held at the Engineers' Club, New York, N. Y., November 18, 1959, with Herman Halperin acting as toastmaster.

Testimonial remarks were presented by L. F. Hickernell, past president of AIEE, and C. T. Hatcher, chairman of the Technical Operations Department, with acknowledgment made by Mr. Del Mar.

Remarks by Past President L. F. Hickernell

The biography of Mr. Del Mar, born in 1880, was outlined by Mr. Hickernell, who stated that "Mr. Del Mar has been known as a stickler for accuracy." The speaker pointed out that Mr. Del Mar became an Associate in 1906, Member in 1914, and Fellow in 1920, having served as manager (now called director) in 1917-21, and first District 3 vice-president in 1921-22. His first committee appointment began in 1914 as a member of the Standards Committee, where he served as a regular member for 12 years and subsequently as a liaison member for 32 years.

Mr. Hickernell paid tribute to Mr. Del Mar, "for his possession of a remarkable ability to combine wit and wisdom in a completely down-to-earth manner." The point was exemplified from his notes on a discussion by Mr. Del Mar of an annual report on cable operation at the 1926 meeting of the Underground Systems Committee of the National Electric Light Association, which noted that "the only difference between failures attributed to overload and those caused by high dielectric loss is a difference of opinion."

In conclusion, Mr. Hickernell cited that, "Through the years of a notable career in electrical engineering, William A. Del Mar has gained and maintained the respect and affection of all of us who have been his colleagues. Because we hold him in such high regard, we wished to make some gesture of appreciation. Through the initiative of Mr. Halperin, our collective good intentions evolved into this very enjoyable occasion. It is good to take part in doing honor to the deserving. And so we say to you, Mr. Del Mar: 'Thank you . . . the pleasure is all ours.'"

Remarks by C. T. Hatcher

Speaking on behalf of the electric utilities, Mr. Hatcher said that Mr. Del Mar's name has been synonymous with the cable business since he became chief engineer of the Habirshaw Wire and Cable Company in 1917. The speaker stated that within 5 years thereafter, he had become associated with Mr. Del Mar in connection with some 45-kv cables which were not operating satisfactorily, and among his notes he had found a sheet showing improvements in paper cables, dated "April 17, 1923, William A. Del Mar." He stated that, "It has been a hobby of Mr. Del Mar since 1917 to develop better cables in general. If good sound advice on some question was desired, one could go to Mr. Del Mar and he knew he was speaking for the rest of the engineers with the utilities." In conclusion, Mr. Hatcher stated that it was a pleasure to have been associated with Mr. Del Mar in the AIEE and the Association of Edison Illuminating Companies (AIEC). On behalf of the electric utilities, appreciation was expressed for his help and guidance, which it was hoped that they might receive for many more years to come.

Acknowledgment by W. A. Del Mar

In response, Mr. Del Mar said that he was happy to hear so many kind words and to know that he had so many friends, and that he was grateful for Mr. Halperin's thoughtfulness in arranging the occasion. He humorously stated that perhaps the award was not given for the reasons alleged, but because he had enunciated the fundamental laws that govern cable dielectrics. "The first law says that when testing dielectrics the unexpected will happen. If it should not, repeat the test and it will." He explained that the second law of dielectrics was discovered more recently; however, it appeared to have become obsolete in recent years. It says, "that when the laboratory develops a new product, action by the laboratory and reaction by the factory are equal and opposite."

In regard to the William Martin Habirshaw Award, which was named in his honor, Mr. Del Mar explained that Mr. Habirshaw was a chemist who pioneered in the first a-c high-voltage underground cables used in America. In the early days, it was customary for chemists to design insulation which then was made of rubber. Mr. Habirshaw designed the 11,000-volt underground cable system of the Cateract Power and Conduit Company which was installed in Buffalo, N. Y., in 1898 and 1899 and gave very satisfactory service for many years. He was one of the founders of the American Chemical Society.

Mr. Halperin, who organized the dinner and acted as toastmaster, read messages received from Dr. R. J. Wiseman, who was in Europe, and Dr. G. B. Shanklin, which expressed heartiest congratulations for a most well deserved honor. Mr. Halperin stated that he had known Mr. Del Mar to be first of all a cable man whom he had met many years ago; that then he had looked like 41 years of age and now like 42, so that he hoped he would be around for many years to come.

PROMINENT cable engineers attending W. A. Del Mar dinner were: *(left to right)* F. M. Hull, chairman, AIEE Insulated Conductors Committee (Detroit Edison Co.); C. T. Hatcher, chairman, AIEE Technical Operations Department (Consolidated Edison Company of New York, Inc.); W. A. Del Mar (consulting engineer, Habirshaw Cable and Wire Division, Phelps Dodge Copper Products Corporation); Herman Halperin, past-chairman, AEIC Cable Engineering Section (Commonwealth Edison Company); L. F. Hickernell (vice-president, Engineering, Anaconda Wire and Cable Company); A. S. Brookes, chairman, AEIC Cable Engineering Section (Public Service Electric & Gas Company).

Five Awards Announced by the AIEE

Nominees Sought by Institute

THE RECOGNITION AWARDS COMMITTEE of the AIEE is seeking nominees for five AIEE awards—in the fields of Electrical Engineering Education, Electrical Measurement, Transmission and Distribution, Electronics, and Telecommunication—to be made October 9-14, 1960, at the Fall General Meeting in Chicago, Ill.

All members of the Institute are eligible to submit nominees. Such nominations are to be made on a form which may be procured from the Secretary of the Recognition Awards Committee, at AIEE headquarters, 33 W. 39th St., New York 18, N. Y. Each form should be accompanied by supporting letters from others who are familiar with the accomplishments and qualifications of the nominee. These forms and letters are due at headquarters not later than May 1, 1960.

Two new AIEE medals will be awarded at the next presentation; these are the Mervin J. Kelly Award in the field of Telecommunication, and the David Sarnoff Award in the field of Electronics. Three previously established awards—the Medal in Electrical Engineering Education, the Morris E. Leeds Award, and the William Martin Habirshaw Award—will also be presented at the meeting.

New AIEE Medals

David Sarnoff

Mervin J. Kelly

The DAVID SARNOFF AWARD established by the Radio Corporation of America, will be given annually in the field of Electronics. The award consists of a 14-carat gold medal, a bronze replica, and a suitably engraved certificate. Preference is given to achievement by a single individual, but if in the opinion of the Institute's Committee the award should be conferred upon a group of individuals who have functioned as a team, the award may be conferred upon such individuals up to three in number. Each member of such a team will receive a gold medal, a bronze replica, and a certificate.

The MERVIN J. KELLY AWARD established by the Bell Telephone Laboratories, Inc., will be presented annually in the field of Telecommunication. The award consists of a cash stipend of $1,000, a bronze medal, and a suitably engraved certificate. In the event that the recipient is a group of individuals, a separate award may be made to each of them in a single year provided that the Institute shall withhold making the award for a number of immediately ensuing years equal to the awards in excess of one so made in a single year.

Previously Established Awards

MEDAL IN ELECTRICAL ENGINEERING EDUCATION

THE MEDAL IN ELECTRICAL ENGINEERING EDUCATION provided for by the Members-for-Life Fund Committee will be given to a teacher of electrical engineering selected for his excellence in teaching and his ability to inspire students to higher achievements; for his contributions to the teaching of electrical engineering through text books and by writings on engineering education; for his active participation in the work of the professional and educational societies; and for his contributions to teaching and the profession through research, engineering achievements, and technical papers.

The award consists of a cash stipend of $500, a bronze medal, and a suitably engraved certificate.

All previous nominations received in connection with the award of this medal must be renominated by letter to Institute headquarters. Supplementary information on these past nominees may, of course, be forwarded with the renomination for attachment to the present file.

Awards of the medal have been as follows:

1956—F. E. Terman
1957—W. L. Everitt
1958—J. F. Calvert
1959—G. S. Brown

THE MORRIS E. LEEDS AWARD

THE MORRIS E. LEEDS AWARD established by the Leeds & Northrup Foundation will be presented annually to an individual or group of individuals who have benefited the arts and sciences by making an outstanding contribution to the field of Electrical Measurement, with special consideration given to the value of contributions made before the candidate has reached his 36th birthday.

The award consists of $500 and a suitably engraved certificate. In the event that the recipient is a group of individuals, the stipend shall be equally divided among the members of the group, and a certificate provided for each.

The first award was made to Dr H. B. Brooks in 1959.

THE WILLIAM MARTIN HABIRSHAW AWARD

THE WILLIAM MARTIN HABIRSHAW AWARD established by the Phelps Dodge Foundation will be made annually to an individual or group of individuals who have made an outstanding contribution to the field of Electrical Transmission and Distribution.

Mr. Habirshaw was a chemist who pioneered in the first a-c high-voltage underground cables used in America. He designed the 11,000-volt underground cable system of the Cataract Power & Conduit Company which was installed at Buffalo, N. Y., in 1898 and 1899, and gave very satisfactory service for many years. He was one of the founders of the American Chemical Society.

The award consists of a cash stipend of $500, a bronze medal, and a suitably engraved certificate. In the event that the recipient is a group of individuals, the stipend shall be equally divided among the members of the group and a medal and a certificate provided for each.

The first award was made to W. A. Del Mar in 1959.

United Engineering Trustees, Inc.
Annual Report for the Year 1958-59

THE ANNUAL REPORT of the Corporation and its Departments for the fiscal year October 1, 1958, to September 30, 1959, has been issued by United Engineering Trustees, Inc. (UET)

UET was established in 1904 by joint action of three national engineering societies: American Institute of Mining, Metallurgical and Petroleum Engineers, Inc., The American Society of Mechanical Engineers, and AIEE, which thereupon became the Founder Societies. In 1916, the American Society of Civil Engineers became a fourth Founder Society, and on May 1, 1958, the American Institute of Chemical Engineers was admitted as a fifth Founder Society. The corporation's charter gives it broad powers for the "advancement of the engineering arts and sciences in all their branches and to maintain a free public engineering library."

The corporate powers and responsibilities are exercised by a Board of 15 Trustees, three from each Founder Society, to which all departments of the corporation (Engineering Societies Library, Engineering Foundation, and Engineering Societies Building) report. The corporation is legally empowered to conduct such combined activities for the societies as may be desired by the Founders.

General

UET assets totaling some $10 million (market value) are exclusively devoted to a multipronged operation for the "advancement of America's engineering leadership":

The area of new scientific and engineering frontiers of knowledge is spanned by the philanthropy of Engineering Foundation.

Engineering knowledge becomes freely available through Engineering Societies Library, one of the finest engineering libraries in the world.

Recognition is awarded for outstanding achievement through the John Fritz Medal Award and the Daniel Guggenheim Medal Award.

UET serves as custodians or trustees of funds for several important research bodies and a federation.

Real estate holdings permit the engineering societies to live and work together under one roof.

We are now well advanced in the design of the new United Engineering Center which will more adequately house the engineering societies located in the present building and permit participation by several other engineering societies. Through this new engineering building,

we believe that the several societies living together under a common roof will form bonds of mutual interest and activity which cannot help but achieve unity in action.

United Engineering Center

Site. The United Engineering Center site includes 37,500 square feet of the block front on the west side of United Nations Plaza between E. 47th and E. 48th Streets, extending west 150 feet on E. 47 Street and 225 feet on E. 48th Street.

The entire site has been cleared and exempted from New York City real estate taxes.

The New Building. During the year, it was necessary to make some modification in the basic design of the building, increasing the size of the tower and reducing the number of floors, but still providing 263,000 square feet gross and 180,000 square feet net, with a tower of 16 stories superimposed on the basic two-story building. In addition to the 5 Founder Societies, 13 other groups plan to participate in the building. Space was allocated to the 18 participating bodies on 14 floors of the tower, making it possible to leave two floors unfinished in the tower, a first provision for expansion.

The entire site will be served by a basement and two stories in which will be located meeting rooms, conference rooms, the Engineering Library, Engineering Index, space for exhibition purposes, and a cafeteria, in addition to storage space and equipment rooms.

In May 1959, Turner Construction Company was selected as general contractor. The architects and engineers completed working drawings on September 2nd, and the selected subcontractors submitted their bids by the end of the fiscal year. At the close of the year, the bids were being analyzed to determine the extent of any changes or revisions necessary to bring the work within the guaranteed limit of cost. Upon completion of this analysis and study, the construction cost of the Center will be finalized. The general schedule calls for occupancy in late 1961.

On October 1, 1959, ground was broken in an impressive ceremony in which the Honorable Herbert Hoover participated.

Fund Raising

The expected cost of the project is $12 million, of which $2,750,000 is required for the site, an estimated $8 million for the building, and the remainder for necessary additional expenses for equipment, administration, legal, accounting, and contingencies.

The funds are being raised by gifts from industry, from the members of the societies, from the sale of the present building, and from the Depreciation Fund.

Industry Gifts Campaign. On October 2, 1959, the total amount subscribed in the Industry Campaign, including a special campaign of Greater New York business, was $4,636,000 from 507 of America's leading corporations; the campaign goal is $5 million.

Dr. M. J. Kelly, chairman of the Industry Fund Campaign, has initiated a termination program in the hope that the goal may be reached during 1960.

Member Gifts Campaign. Eleven national bodies made up of individual members are to occupy the building. These societies have accepted individual fund raising quotas, the total of which is $3,780,000. As of October 2, 1959, $2,667,811 has been secured in subscriptions, leaving an unattained quota of over $1,100,000.

Vigorous efforts are being carried on by all of the societies to attain their quotas early in 1960.

Occupancy of United Engineering Center. In addition to the five Founder Societies, prospective Associate Societies which have expressed an interest in participating in the new United Engineering Center are: American Institute of Consulting Engineers; American Institute of Industrial Engineers; American Society of Heating, Refrigerating and Air-Conditioning Engineers; American Welding Society; Illuminating Engineering Society; and Society of Women Engineers. In addition, several joint bodies will be included.

The responsibility for management, construction, and administration of the United Engineering Center will rest with the Board of Trustees. However, operation of the Center will be handled by an advisory committee with representation from both Founder and Associate Societies; one of the principal responsibilities of this committee will be to recommend to the Board of Trustees, from time to time, proper space assessment rates.

Similarly, the Associate Societies will have a voice in the management of Engineering Societies Library and will share in its financial support on a uniform basis.

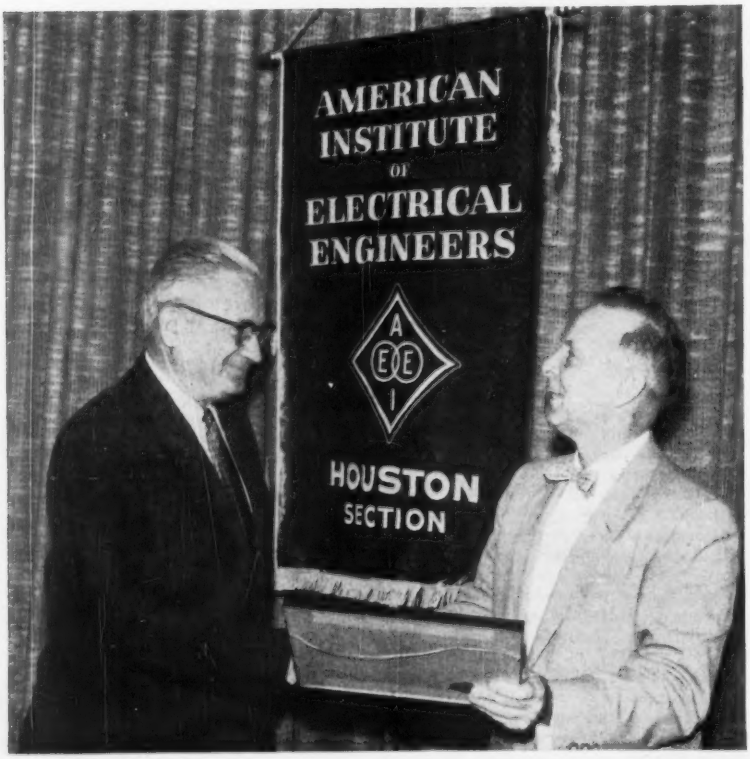
The Founder and Associate Societies, together with their several joint agencies, will make the new United Engineering Center the focal point of American engineering.

Engineering Societies Library

Recognizing that the strength of our technology depends to a large extent upon the organization and availability of the world's engineering literature, the Engineering Societies Library, as the educational arm of UET, endeavors to provide engineers with a type of service unmatched elsewhere in the world. Evidence of the usefulness of the library is demonstrated by a 23% increase in the use of the library in the last 2 years. The library translation service covers the various languages of the world.

The Library Board has already initiated specific planning which will permit the development of an even more useful library in the proposed new United Engi-

Past Chairman Certificate Presented



A PAST CHAIRMAN certificate was presented to V. P. Paar (*left*), district plant engineer of the Southwestern Bell Telephone Company, by National Director N. F. Rode (*right*) at a meeting of the Houston Section, AIEE. Mr. Paar served as chairman of the Section for 1958-59.

neering Center. With the expansion of facilities, the library will be able to extend still further the quantity and the quality of its services to all engineers and to industry.

Engineering Foundation

The Engineering Foundation, as the research arm of UET, endeavors to advance the frontiers of man's engineering knowledge.

The Engineering Foundation is currently developing a new policy which will tend to utilize more greatly the highly skilled talent in our Engineering Societies' membership to define voids in our knowledge and establish needed research in such areas.

Medal Awards

UET also is custodian of two medal awards: The John Fritz Medal Award "for scientific or industrial achievement in any field of pure or applied science," and the Daniel Guggenheim Medal Award for "notable achievements in the advancement of aeronautics."

The 1960 recipient of the John Fritz Medal is G. A. Price for his inspirational leadership, industrial pioneering, and personal initiative in marshaling the creative forces of research and engineering to the cause of developing atomic power for the national defense and for the human welfare.

The 1959 recipient of the Daniel Guggenheim Medal is Sir George Edwards for a lifetime devoted to the design of military and commercial aircraft culminating in the successful introduction into worldwide commercial service of the first turbine-powered propeller driven aircraft.

Other UET Activities

UET serves as fiscal agent for the following organizations: Alloys of Iron Research, Column Research Council, Corrosion Research Council, Engineers' Council for Professional Development, Reinforced Concrete Research Council, Research Council on Riveted and Bolted Structural Joints, Thermal Resistivity Characteristics of Soils, Welding Research Council.

Finances

As of the end of the fiscal year 1958-59, UET's Balance Sheet Assets totaled some $8.9 million, an increase of $2.2 million more than the previous fiscal year. The total real estate assets of UET are listed as $6.37 million. There are no mortgages or notes outstanding.

UET's investments, excluding current funds and Agency Funds, are represented by three investment portfolios: Combined Fund, Blanche H. McHenry Memorial Fund, and the Depreciation Fund. The Combined Fund totals approximately $2.34 million (market) of which 80.6% or $1.89 million is held in trust for the Engineering Foundation, and the remaining 19.4% or $450,000 is held in trust for the Engineering Societies Library. No part of the principal of the Combined Fund may be used by either department. An additional portfolio, the Blanche H. McHenry Memorial Fund is held in trust for Engineering Foundation, and it totals some $454,000 market value; this principal must also remain intact. The Depreciation Fund, totaling $591,203 market value, is a property fund which can readily be liquidated in connection with the United Engineering Center project. It is composed mainly of U. S. Treasury securities and American Telephone and Telegraph stock. The income based on book value of these funds during the year is as follows: Combined Fund—5.46%, Blanche H. McHenry Memorial Fund—3.68%, Depreciation Fund—2.77%.

The UET invested funds total $2.33 million, represented by U. S. Treasury Bills that can be quickly converted into cash. Fund raising pledges up to September 30, 1959, total some $7.3 million of which more than $4.7 million represents cash actually received.

All securities are held in custody by Chemical Bank New York Trust Company, customers' securities department. All accounts are audited twice yearly by Haskins and Sells, certified public accountants.

Professional Advisers

Advisers are retained by the Board of Trustees on all phases of its work in order to obtain the best information available.

Financial Counsel—W. Barton Cummings, vice-president, Chemical Bank New York Trust Company.

Investment Adviser—Wood, Struthers & Company, M. S. Harrison, partner.

Legal Counsel—Simon Presant.

Consulting Architects—Shreve, Lamb & Harmon Associates.

Consulting Actuary—George B. Buck.

Insurance Advisers—Frank & DuBois.

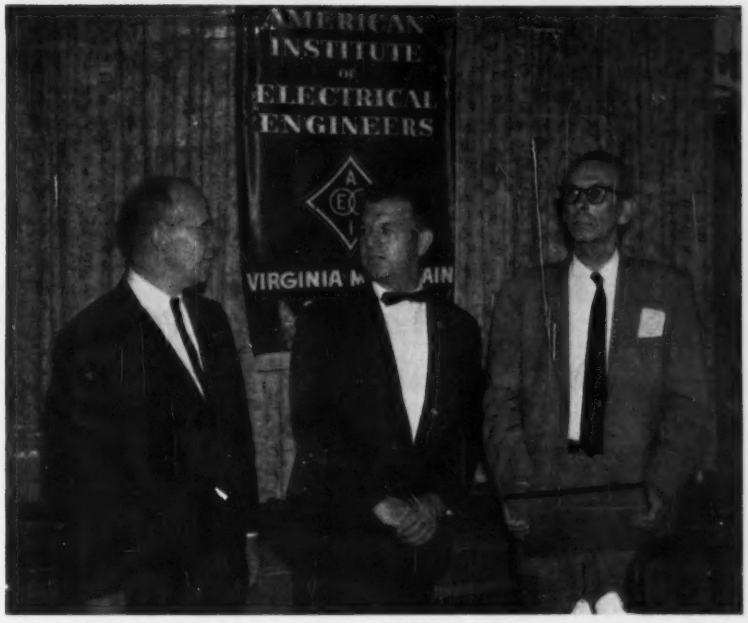
Auditors—Haskins & Sells, certified public accountants.

Appreciation

I wish to thank all members of the Board of Trustees for their wise counsel and outstanding achievements during my term as president. On their behalf, sincere thanks are extended to the entire UET staff including Engineering Societies Library and Engineering Foundation for their outstanding work in the conduct of the affairs of the Corporation during the past year.

Respectfully submitted,
Andrew Fletcher
President

Fellows Receive Certificates



CERTIFICATES of transfer to the grade of Fellow in AIEE were presented at a meeting of the Virginia Mountain Section, AIEE, to J. S. Jamison, Jr. (*left*), professor and head of the electrical engineering department at Virginia Military Institute, and H. A. Clarke (*right*), superintendent, system station department, Appalachian Power Company. E. C. Rankin (*center*), past chairman of the Section, made the presentation. Both Fellows had been elected at a Board of Directors meeting June 26, 1959.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grade, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

J. F. Fairman Named Recipient of Edison Medal

The Edison Medal Committee of the AIEE has awarded the Edison Medal for 1959 to J. F. Fairman (AM '20, M '27, F '35, HM '55), past president of the Institute and senior vice-president, Consolidated Edison Company of New York, Inc., New York, N. Y. The presentation of the medal will take place during the general session of the 1960 Winter General Meeting, at the Hotel Statler, New York, N. Y.

The citation which will accompany the medal reads as follows:

> "For outstanding performance in improving the design of large electric power systems; for far-sighted leadership in atomic power development; and for unremitting efforts to improve the engineering profession."

Mr. Fairman was born April 8, 1896, in Big Rapids, Mich. He attended the University of Michigan where he received a B.S.E. degree in 1918. After graduation, he served in the U. S. Army as a second lieutenant. Upon his discharge, he joined the Westinghouse Electric and Manufacturing Company as a student engineer. In 1919, he returned to the University of Michigan as an instructor in the College of Engineering. He received an M.S. degree from the University in 1921 and became an assistant professor in 1922.

In 1925, Mr. Fairman was employed by the Brooklyn Edison Company in its electrical engineering department as assistant outside plant engineer. He became outside plant engineer and assistant electrical engineer the following year. In 1928, the Brooklyn Edison Company became a subsidiary of Consolidated Gas Company of New York. In 1932, he was placed in charge of the electrical engineering department of Brooklyn Edison, a position he continued to hold when the engineering staffs of the companies in the Consolidated Edison System were merged in 1937.

In 1940, he was named assistant vice-president, at which time he had responsibilities for design, inventory, purchasing, and stores. In 1945, he was elected vice-president and placed in charge of electric and gas production and operation.

During 1951 and 1952, Mr. Fairman was on leave to the U. S. Government where he served as deputy administrator and then administrator of the Defense Electric Power Administration.

On his return to his post as vice-president of Consolidated Edison in 1952, he was placed in charge of engineering and rates. In 1957, he was named senior vice-president.

Mr. Fairman has had over-all responsibility with Consolidated Edison for the nuclear electric generating station the company is building at Indian Point. He has also been active in the nation's over-all effort to achieve economic nuclear electric power. He has been chairman of the Edison Electric Institute's Technical Appraisal Task Force on Nuclear Power since it was established in 1956 and is chairman of the National Association of Manufacturers' Committee on Nuclear Energy. He is a member of the New York State Atomic Energy Advisory Committee. He is also a vice-president and director of the Atomic Industrial Forum.

J. F. Fairman

Since his teaching days, Mr. Fairman has been actively interested in promoting the engineering profession. He has served on various committees of the Association of Edison Illuminating Companies and was president of the New York State Society of Professional Engineers in 1942-44.

Mr. Fairman received the Distinguished Service Award of the U. S. Department of the Interior in 1952, and was awarded an honorary degree of doctor of engineering from the University of Michigan in 1953.

Mr. Fairman has served as AIEE president (1949-50), director (1946-49), District 3 vice-president (1944-46), and is a Member for Life. He is an AIEE representative to the United Engineering Trustees, Inc. (UET) (1957-60), and was a representative to the Board of Trustees, UET (1947-57); Engineers' Council for Professional Development (1938-44); Engineers Joint Council (alternate 1948-49), (representative 1949-52); General Electric Educational Fund Committee (1949-51); John Fritz Medal Board of Award (1949-54); and World Power Conference, Executive Committee, U. S. National Committee (1949-50).

He was a member of the following AIEE Committees: Safety Codes (1931-34); General Power Applications (1934-36); Electrical Machinery (1936-37); Board of Examiners (1941-44); Education (1941-42); Technical Program (1941-42, 1945-47); Executive (1944-52, chairman 1949-50); Finance (1944-46); Planning and Co-ordination (1945-52, chairman 1945-47); Edison Medal (1945-57); Institute Publicity (1946-47); Board of Directors (1944-52); AIEE Retirement System, Board of Trustees 1953-57); and Recognition Awards (1957-58).

Wear Your ◆ AIEE Badge

Nominating Committee for 1960 Officers Named

The AIEE Nominating Committee* will meet in the Boston Room, Statler-Hilton Hotel, New York, N.Y., 9:00 a.m., February 1, 1960, during the Winter General Meeting of the Institute, to nominate candidates for AIEE offices to be voted upon by the membership in the Spring of 1960. Representatives receive travel allowance. Alternates are required to attend only if called upon to serve in place of their representative.

Members of the committee, as of December 1959, are as follows:

Representing the 14 Geographical Districts:

1. C. J. Fitch, International Business Machines, Endicott, N. Y.
2. F. S. Fehr, Metropolitan Edison Co., P. O. Box 542, Reading, Pa.
3. W. G. Vieth, Western Union Telegraph Co., 60 Hudson St., New York 13, N. Y.
4. H. W. Oetinger, Duke Power Company, Charlotte 1, N. C.
5. W. M. Ballenger, General Electric Co., 840 S. Canal St., Chicago 80, Ill.
6. J. C. Livesay, Colorado Central Power Co., 5470 S. Broadway, Englewood, Colo.
7. H. R. Vaughan, Westinghouse Electric Corp., 101 W. 11th St., Kansas City 6, Mo.
8. M. G. Lewis, Bechtel Corporation, 101 California St., San Francisco 11, Calif.
9. H. B. Hodgins, Westinghouse Electric Corp., 235 West South Temple St., Salt Lake City 1, Utah
10. Rene Dupuis, Quebec-Hydro Electric Commission, 107 Craig St., West, Montreal 1, Que., Canada
11. D. T. Michael, Cincinnati Gas & Electric Co., Box 960, Cincinnati 1, Ohio
12. L. J. Weed, Boston Edison Company, 1165 Massachusetts Ave., Boston, Mass.
13. M. L. Hurstell, New Orleans Public Service Inc., 317 Baronne St., New Orleans, La.
14. J. W. Rittenhouse, Hi-Voltage Equipment Co., 4000 E. 116th St., Cleveland 5, Ohio

Alternates:

1. J. W. Becker, Allis-Chalmers Manufacturing Co., 472 S. Salina St., Syracuse 10, N. Y.
2. K. J. Granbois, Pennsylvania Power & Light Co., R.D. No. 2 Safe Harbor Plant, Conestoga, Pa.
3. R. M. Franklin, Sperry Gyroscope Co., Great Neck, L.I., N. Y.
4. B. V. Martin, Westinghouse Electric Corp., Charlotte 1, N. C.
5. S. N. Witts, Northern States Power Co., 15 S. 5th St., Minneapolis 2, Minn.
6. W. L. Smith, Allis-Chalmers Manufacturing Co, Denver, Colo.
7. W. C. Fowler, Sangamo Electric Corp., 2424 Colonial Parkway, Fort Worth 9, Texas
8. R. N. Keene, 2182 56th Ave., Sacramento 22, Calif.
9. R. A. Radford, Engineering Department, Utah Power & Light Co., Salt Lake City, Utah
10. G. F. Tracy, Electrical Building, University of Toronto, Toronto 5, Ont., Canada
11. F. Von Voigtlander, Cummins & Barnard, Inc., 109 E. Washington St., Ann Arbor, Mich.
12. E. E. Linden, Narragansett Electric Company, Providence, R. I.
13. B. H. Bell, New Orleans Public Service Inc., 317 Baronne St., New Orleans, La.
14. W. H. Osterle, West Penn Power Co., 800 Cabin Hill Drive, Greensburg, Pa.

Representing the 6 Technical Divisions:

Communication—C. E. Dean, Hazeltine Corp., 5825 Little Neck Parkway, Little Neck 62, N. Y.

General Applications—L. R. Larson, The Martin Company, Box 179, Denver 1, Colo.

*See Constitution and Bylaws (*Organization Manual*, p. 146 pp. 152-53) and *Electrical Engineering*, November 1959, (p. 1130-31).

Industry—R. H. Whaley, Eli Lilly and Co., 740 South Alabama St., Indianapolis 6, Ind.
Instrumentation—P. K. McElroy, General Radio Company, 22 Baker Ave., West Concord, Mass.
Power—F. L. Lawton, Aluminum Laboratories, Ltd., 1800 Sun Life Building, Montreal, Que., Canada
Science & Electronics—D. E. Trucksess, Bell Telephone Laboratories, Inc., 463 West St., New York 14, N. Y.

Alternates:

Communication—L. G. Abraham, Bell Telephone Laboratories, Inc., Murray Hill, N. J.
General Applications—G. E. Schall, Underwriters Laboratories, Inc., 161 6th Ave., New York, N. Y.
Industry—J. F. Deffenbaugh, Federal Machine & Welder Co., Overland Ave., Warren, Ohio
Instrumentation—Ferdinand Hamburger, Jr., Johns Hopkins University, Baltimore 18, Md.
Power—J. H. Kinghorn, American Electric Power Service Corp., 30 Church St., New York, N. Y.
Science & Electronics—E. L. Harder, Westinghouse Elec. Corporation, Analytical Department 4-L-38, East Pittsburgh, Pa.

Representing the Board of Directors:

Hendley Blackmon, Westinghouse Electric Corp., 3 Gateway Center, P. O. Box 2278, Pittsburgh 30, Pa.
W. H. Chase, Ohio Bell Telephone Co., 750 Huron Rd., Cleveland 15, Ohio
W. R. Clark, Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia 44, Pa.
R. B. Gear, Commonwealth Edison Co., 72 W. Adams St., Chicago 90, Ill.
E. W. Morris, Westinghouse Electric Corp., 410 Bush St., San Francisco Calif.
J. C. Strasbourger, Muncie Engineering, Inc., Box 765, Muncie, Ind.

Alternates:

W. R. Brownlee, Southern Services, Inc., Birmingham, Ala.
E. I. Green, Bell Telephone Laboratories, Inc., Murray Hill, N. J.
L. M. Robertson, Public Service Co. of Colorado, Denver, Colo.
A. A. Johnson, Westinghouse Electric Corp., East Pittsburgh, Pa.

ECPD Develops "Kit" for Young Graduate Engineers

A new professional development "Kit" based on the "First Five Years" program of the Engineers' Council for Professional Development (ECPD) has been announced.

George Lobingier of AIEE is vice-chairman of the Committee on Development of Young Engineers (formerly "Training") for 1959-60. Cornelius Wandmacher of the American Society of Civil Engineers is the retiring chairman. Mr. Wandmacher is succeeded by John Gammell of the American Society of Mechanical Engineers, new chairman for 1959-60.

The new professional development Kit for young graduate engineers contains the following items:

A Professional Guide for Young Engineers—1949, selected professional papers of W. E. Wickenden, including "The Second Mile." 48 pages.

The First Five Years, a brochure outlining the complete 6-point professional development program for young graduate engineers.

Selected Reading for Young Engineers, a compilation of 148 recommended books in humanistic-social fields.

Personal Appraisal Form, a questionnaire to aid in evaluating professional progress and in planning for the future.

Canons of Ethics, a statement of ethical principles in professional life, relations with the public, with clients and employers, and with other engineers.

Faith of the Engineer, a brief statement of the heritage and the responsibilities of the profession.

All of the items are included in a convenient Kit folder with envelope, which is designed to become a professional development file. The cost of the complete Kit is $2, and quantity discounts are available on request.

The new Kits are now available at the New York headquarters office of the ECPD, 33 W. 39th St., New York 18, N. Y.

PRESENTING a copy of the new professional development "Kit" to John Gammell (*center*), supervisor of graduate training, Allis-Chalmers Company, is Cornelius Wandmacher (*left*), associate dean of engineering, University of Cincinnati, while George Lobingier (*right*), manager of education, Westinghouse Electric Corporation, looks on. The "First Five Years" program of the Engineers Council for Professional Development is the basis for the new professional development Kit for young engineers.

Partial Program Announced for Nuclear Congress, April 1960

A partial program of sessions planned for the 1960 Nuclear Congress, to be held in the Coliseum, New York, N.Y., April 4-7, 1960, has been announced by Dr. Clarke Williams, chairman of the nuclear engineering department of the Brookhaven National Laboratory, Upton, N.Y., and chairman of the Nuclear Congress.

The program will include several papers on instrumentation, reactors, isotopes, health, and aircraft propulsion—all of interest to those in the electrical and electronics fields.

The congress, a gathering of representatives from all areas of the nuclear field, is sponsored by 28 leading engineering, scientific, management, and technical organizations. It consists of the 6th Nuclear Engineering and Science Conference, the 8th Atomic Energy in Industry Conference of the National Industrial Conference Board, and the 6th International Atomic Exposition.

The exposition, which was started in 1954, will include at least 130 exhibits of the manifold products and services available for the peaceful use of atomic energy. More than 1,000 requests for information regarding participation in the exhibit have been received from firms all over the world, indicating an exceptional interest.

The congress sessions are expected to draw the largest audience of engineers and related specialists, as well as the largest representation of industrial and scientific exhibitors ever to attend an event of this kind.

The estimate of this record-breaking attendance is based on the fact that 35% of the nation's 600,000 engineers live and work within 300 miles of New York City, and many others have headquarters there.

The theme of the meeting, according to E. B. Gunyou, program committee chairman of the Nuclear Congress, will be "What Will the Future Development of Nuclear Energy Demand from Engineers?" This question will be approached through a series of reports, papers, and discussions on a wide variety of subjects related to the peaceful use of atomic energy. This, at present, includes: plant construction and site location; public health problems and Federal-state regulations; water supply and waste disposal; the use of metal, ceramic, and organic materials; problems of fuel technology; development of nuclear

standards; industrial applications of isotopes; nuclear propelled aircraft and space vehicles; power reactors now, and in the next 10 years; research reactors and radiation facilities; progress in reactor instrumentation; and advanced reactors and fuel cycles.

Wives of Seattle Members Organize Auxiliary to Section

The Women's Auxiliary to the Seattle Section, AIEE, was formed November 5, 1959, at a luncheon meeting at the Washington Athletic Club.

Mrs. Roy Kistler, founder of the auxiliary, called the meeting to order and gave a short resume of the organizing committee's activities. She introduced Mrs. Norman Carson as temporary chairlady who then conducted the meeting.

Mrs. T. J. Martin presented the resolution to form the auxiliary.

The objectives of the auxiliary are to further social contacts among wives of members of the AIEE, to advance education in electrical engineering, and to cooperate in furthering the objectives of the AIEE.

The organizing committee comprised: Mrs. Roy Kistler, Mrs. Norman Carson, Mrs. Gordon Jorgensen, Mrs. F. R. Bergseth, Mrs. T. J. Martin, Mrs. Scott McDermott, Mrs. J. W. Scott, and Mrs. Stanley Yates.

Officers who were elected are: Mrs. Norman Carson, chairlady; Mrs. Scott McDermott, vice-chairlady; Mrs. John Scott, secretary; and Mrs. Stanley Yates, treasurer.

The group expects to meet about five times a year. The next meeting will be held January 7, 1960. All wives of members in the Seattle area may attend. Reservations should be made with Mrs. Jorgensen or Mrs. Bergseth.

Foundation Provides Books for Asian Students

Various book projects to assist education in Asian countries require the Books for Asian Students Program each year to seek the co-operation of individuals who are in touch with sources of books.

The book program, a project of The Asia Foundation, had sent, by April 1959, more than one million books and a quarter of a million journals to thousands of recipients in Asia. Program materials are of a selective nature meeting rigid criteria and are sent to recipients with known, definite needs.

Students and professors of 400 American campuses as well as librarians, publishers, booksellers, civic organizations, and individuals have participated in this program. Some 90 American publishers have participated so generously that their contributions furnish texts for more than 2,000 classrooms.

University, college, and secondary level books in good condition, published after 1945, are needed. Works by standard authors published before 1945 are also acceptable.

The Asia Foundation will pay transportation costs from the donor to San Francisco and then to Asia. Books may be shipped by the following methods only: book rate parcel post in packages under 70 pounds, reimbursement for which will be sent when the donor's postal receipt arrives; or, if the quantity is large, by motor freight (truck) collect, but not Railway Express or moving van. All shipments or questions concerning the categories, criteria, shipping, and program details should be addressed to: Books for Asian Students, 21 Drumm St., San Francisco 11, Calif.

Subscription Prices of Publications Increased

The price of everything purchased today—whether it be clothing, food, housing, or an automobile—is higher, as the result of a steady increase over the years. Publications are no exception. Since the bimonthly publications were inaugurated in July and August of 1952, there has been a considerable inflationary increase in the costs of printing, paper, salaries, and overhead. Also, rapid advances in all phases of technology have resulted in an increased volume of technical material to be published in order to keep pace with the times. For example, when the bimonthly publications were inaugurated in 1952, the total annual volume in a compact format was 2,068 pages; whereas in the same compact format for the calendar year 1959, the total volume will be more than 3,500 pages.

The Institute is a nonprofit organization and derives no net income from the sale of its publications to members. At the close of the last fiscal year, April 30, 1959, the deficit from this part of the publishing operation was $182,860 as shown in the accompanying tabulation.

Net Cost of Bimonthlies and Transactions Fiscal Year May 1, 1958–April 30, 1959

	Expenditure	Income	Deficit
Bimonthlies	$204,454	$37,428	$167,026
Transactions	50,163	34,329	15,834
TOTAL	$254,617	$71,757	$182,860

To make these publications more nearly self-supporting, the Board of Directors at its meeting of October 16, 1959, approved increasing the annual subscription price to the first bimonthly for members from $2.50 to $5.00. This will become effective May 1, 1960. Members are allowed one subscription to each of three bimonthly publications at $5.00 each, and additional subscriptions to the same bimonthly may be obtained at the nonmember rate of $8.00 each.

At the same time, nonmember subscription prices to all three parts of the *Transactions* (beginning with Volume 77 for 1958) were increased from $15.00 to $20.00, and the nonmember subscription to any two parts was increased from $12.00 to $15.00.

The annual combination subscription to *Electrical Engineering* and the *Transactions* was terminated; but nonmembers may subscribe to each of these publications separately at the prices listed on p. 24A of this issue.

Complete member and nonmember subscription prices to all AIEE publications appear on p. 24A.

Royal C. Crooks Photo

OFFICERS of the Women's Auxiliary to the Seattle Section, AIEE, are: (left to right) Mrs. Scott McDermott, vice-chairlady; Mrs. Norman Carson, chairlady; Mrs. Stanley Yates, treasurer; and Mrs. John Scott, secretary. The founder of the auxiliary is Mrs. Ray Kistler (right).

The bimonthly publications contain all officially approved technical papers collated with discussion (if any) in the following three broad fields of subject matter, each issued six times a year:

	No. of Pages
Communication and Electronics (Six issues)	1,160
Applications and Industry (Six issues)	550
Power Apparatus and Systems (Six issues)	1,820
	3,530

The number of pages in each publication in six consecutive issues, which correspond with Volume 78 of the 1959 *Transactions* and contain all the approved technical papers and discussions presented in the calendar year 1959, will be in excess of the quantities shown annually.

Collectively, with more than 3,500 pages of technical material which has been sponsored and carefully screened by more than 50 technical committees, these publications still probably represent the greatest buy in technical literature for the least dollars.

Standards

On January 4, 1960, a general increase in the prices of Standards Publications became effective, and charges for the "Report," "Trial Use," and "Proposed" categories were inaugurated. Copies of the new listing may be obtained from AIEE Headquarters.

IFAC Will Meet June 2, 1960, in Moscow

The First International Federation of Automatic Control (IFAC) Congress, of which the American Automatic Control Council is the American member, will be held June 27–July 8, 1960, in Moscow, USSR.

Those planning to attend this congress may obtain information on arrangements from: Secretary, American Automatic Control Council (Editor, *Control Engineering*), 330 W. 42nd St., New York 36, N. Y.

The secretary should be informed of plans to attend the congress by the first week in February. Each person who attends should give his full name, date of birth, title, place of work, and address, so that the Council may assemble for IFAC a complete list of persons who will attend from the United States. Registration for the congress will cost those who will not present papers $20 before March 31, 1960, and $30 afterward. Authors may register for $15 before that date and for $20 later.

Those who register in advance of March 31 will receive a full set of preprints in English. Buttersworth Scientific Publications, the proceedings publisher, will distribute the preprints sometime in April.

Intourist, the Soviet tourist agency, will handle all travel and accommodations within the USSR.

Since its organization last year, IFAC has directed its technical efforts primarily toward its first congress. The host for the conference will be Dr. A. M. Letov of the USSR Institute of Automatics and Telemechanics. He has advised that 321 authors of the USSR National Committee of Automatic Control have submitted abstracts and have been invited to complete their papers for final selection. The Soviet society is expected to pick about two-thirds of that number for presentation.

The tentative program allows 6 days for the presentation of papers and 3 full days for prearranged visits to plants and technical institutes.

A brief program with number of papers follows:

Section I. Theory

Continuous systems (38)
Discrete systems (18)
Stochastic problems (18)
Optimum system design (22)
Self-adaptive systems (13)
Remote control (5)
Problems in mathematics (27)

Section II. Components

Electric and magnetic elements (13)
Computing, programming devices (2)
Centralized control and telemetry (10)
Electric final control elements (9)
Pneumatic transducers, systems (13)
Pneumatic computers (6)

Section III. Application

Machine building (8)
Power and heat systems (16)
Chemical and oil refining (16)
Electric drives (12)
Continuous processes (14)
Nonclassified problems (52)

AIEE FELLOWS ELECTED

Board of Directors Meeting, October 16, 1959*

Rawson Bennett II (AM '38, M '45), rear admiral and chief of naval research, Navy Department, U.S. Navy, Washington, D.C., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to accelerated and co-ordinated naval research, particularly in electronics." Admiral Bennett was born June 16, 1905, in Chicago, Ill., and was appointed to the U.S. Naval Academy, Annapolis, Md., from California in 1923. Graduated and commissioned an ensign in June 1927, he was advanced subsequently to the rank of captain in March 1945. Following graduation, in 1927, he was assigned to duty aboard ship, until June 1934, when he returned to Annapolis for postgraduate instruction in radio (electronic) engineering. He completed the course in May 1936 and was assigned to the University of California, Berkeley, where he received the M.S. degree in electrical engineering. After this, he returned to sea duty, and in April 1938, he joined the staff of Commander Destroyer Division Nineteen, later redesignated Destroyer Division Fifty, and served as radio and sound officer until June 1941. Starting in July 1939, he set up and conducted the technical program of the first Fleet Sound School at San Diego, Calif., as additional duty. In July 1941, he reported to the Bureau of Ships, Navy Department, Washington, D. C. There he served first as head of the Underwater Sound Design Section, Radio Division, and later as head of Electronics Design Division, during 1943-46. Admiral Bennett was awarded the Legion of Merit with a citation stating that he "designed sonic and supersonic underwater sound apparatus so urgently required by the Fleet for the destruction of Axis submarines and Japanese shipping." Detached from the Bureau of Ships in August 1946, he reported as director of the U.S. Navy Electronics Laboratory, Point Loma, San Diego, where he accomplished the postwar expansion of that laboratory. In July 1950, he was ordered to Washington, D. C., where he set up and became the first director of the Electronics Production Resources Agency, Department of Defense. In October 1951, he reported to the Bureau of Ships, Navy Department, where he was assigned duty as head of the Mine Warfare Branch. He next served as naval inspector of machinery and naval inspector of ordnance, General Electric Company, Schenectady, N. Y. In February 1954, he reported to the Bureau of Ships for duty as assistant chief of the Bureau for Electronics. In December 1955, he was appointed chief of naval research, with the rank of rear admiral. In January 1959, he was reappointed chief of naval research for a second term. Admiral Bennett is a fellow of the Institute of Radio Engineers, the Acoustical Society, the American Association for the Advancement of Science, and an honorary fellow of the American Rocket Society.

U. S. Navy Photo
Rawson Bennett, II

*Biographies of other AIEE members transferred to the grade of Fellow at the Board of Directors meeting on October 16, 1959, appeared in the December 1959 issue.

E. A. Benson

Erick Alfred Benson (M '48), project manager of the Parker-Davis Project of the Bureau of Reclamation, U.S. Department of Interior, Phoenix, Ariz., has been transferred to the grade of Fellow in the AIEE ". . . for contributions of engineering innovations to construction and operation of a large hydro project." Mr. Benson was born December 20, 1907, in Wetaskiwin, Alta., Canada, attended Montana State College in Bozeman, Mont., in 1931-35, and graduated with a B.S. degree in electrical engineering in 1935. He entered the federal service in October 1937 as a junior engineer for the Corps of Engineers of the Department of the Army at Fort Peck, Mont. In 1939, he was transferred to the Bureau of Reclamation as an electrical engineer on the Parker Dam Power Project, Parker Dam, Calif. In 1943, he was made superintendent of power for that installation and supervised the maintenance operations and construction operations in the extension of the system. In 1950, Mr. Benson was named assistant project manager in charge of power operations. He selected and trained personnel for an expanded and complex interconnected power system. He introduced novel engineering methods which resulted in economical operations. Some of these were the installations of carrier equipment and telemetering supervisory controls during the project development. In 1954, he was named project manager of this expanded project and has supervised the operations, maintenance, and improvements of a system covering three states. He promoted efficiency in the operation by recommending conversions to automatic control and recording devices and other progressive innovations to keep the cost of operating low in the face of rising labor and material costs. He was responsible for the engineering involved in the design and installation of equipment to permit the operation of two large hydroelectric plants with one operator per shift. He was responsible for the installation of self-guided tours at Parker Dam and Davis Dam, and the installation of microwave, telemetering carrier communication, and the adapting of improved devices to local project needs. He pioneered and inaugurated helicopter patrol of transmission lines of more than 1,600 circuit miles. He has initiated and promoted electronic data processing for record keeping and other purposes. Mr. Benson is a member of Tau Beta Pi.

L. A. Finzi

Leo Aldo Finzi (AM '40, M '49), Buhl professor of electrical engineering at the Carnegie Institute of Technology, Pittsburgh, Pa., has been transferred to the grade of Fellow in the AIEE " for contributions to electrical engineering education and the theory of magnetic amplifiers." Prof. Finzi was born December 16, 1901, in Padova, Italy, and studied at the University of Naples, the Institute of Technology at Aachen, Germany, and Rome University. During 1926-31, he was a designer of electrical machines with the Hochspannungs ges. M.b.H. of Cologne, Germany, and in 1931-38, he was section engineer of power generation and transmission for Ente Elettrico Volturno of Naples and adjunct professor of electrical technologies at Naples University. He came to the United States in 1939 and joined the General Engineering Laboratories of Westinghouse Electric Corporation in charge of the Impulse Laboratory at East Pittsburgh, Pa. Since 1946, he has been on the faculty of the Carnegie Institute of Technology and dealt with undergraduate and graduate teaching and the conduct and supervision of research. In 1955 he received an award from the Carnegie Corporation of New York for his "outstanding" quality of teaching and "his influence upon the teaching of others," and was appointed to the Buhl Chair of Electrical Engineering. Prof. Finzi is the author or coauthor of some 40 papers in European and American journals on field theory, analyses of electrical machines, lightning protection, and transformers, and is well-known for his contributions to the theory of nonlinear magnetic devices. In recent years, he has been an invited lecturer on this subject at various industrial organizations. He is a member of the American Society for Engineering Education, Eta Kappa Nu, Tau Beta Pi, and Sigma Xi. He has served on the AIEE Basic Sciences Committee (1949-53) and Magnetic Amplifiers Committee (1951-60).

Paul Homer Goodell (AM '40, M '46), chief engineer of the Bettcher Manufacturing Corporation, Cleveland, Ohio, has been transferred to the grade of Fellow in the AIEE ". . . for contributions to applications of electricity to industrial heating." Mr. Goodell was born May 25, 1908, in Wickliffe, Ohio, and studied electrical engineering at the University of Cincinnati, Ohio. His career in electrical heating began in 1939 when he became manager of the Radiant Heating Division of C. M. Hall Lamp Company, Detroit, Mich. He presented the first Institute paper on radiant heating, establishing many of the factors covering this method of heat transfer. In 1943, he became manager, industrial heating sales, Trumbull Division, General Electric Company, and served as a heating consultant on the Manhattan project. He was made vice-president of Catalytic Combustion Corporation, Detroit, Mich., in 1954 and served in this position until his recent association with Bettcher Manufacturing Corporation. He has written many papers on industrial heating of which the latest was on "Industrial Ovens Designed for Air Polution Control," presented at the 1959 annual meeting of the Air Pollution Association. Mr. Goodell is a member of the Odor and Gas Treatment Committee of the Air Pollution Control Association, the American Society of Mechanical Engineers, the National Society of Professional Engineers, and a fellow of the Illuminating Engineering Society. He holds several patents on electric heating equipment. He is a registered professional engineer of the State of Ohio. In 1948, he was appointed chairman of the Institute's Radiant Heating Subcommittee. He served on the AIEE Electric Heating Committee (1947-60, chairman 1951-53). He was general chairman of the Institute's first technical conference covering all phases of Industrial Electric Heating, held May 1953 in Detroit, Mich. He has served as the Institute's liaison representative on the Oven and Furnace Standards Committee of the National Fire Protection Association. He was a member of the AIEE Industry Division Committee (1951-53).

P. H. Goodell

William Rodgers Johnson (AM '37, M '47), chief electric generation and transmission engineer, Pacific Gas and Electric Company, San Francisco, Calif., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the development of a major electric generating and transmission system." Mr. Johnson was born October 23, 1914, in Avant, Okla., and received his B.S. degree in electrical engineering in 1937 from the Georgia Institute of Technology. After one year in electrical design work for the Tennessee Valley Authority, he accepted a research assistantship at the Ryan High-Voltage Laboratory of Stanford University. He received the electrical engineering degree

from Stanford in 1940 and has been employed by Pacific Gas and Electric Company continuously since that time. His first employment for this utility was as an electrical inspector on the construction of the Oleum Steam Plant. He was transferred to the engineering department in 1942 and assumed his present position in 1951. In the engineering department, his activities have related chiefly to power system planning and to the design of electric generating plants and transmission facilities. Mr. Johnson has been the author or coauthor of a number of papers dealing with these subjects. He is a past chairman of the San Francisco Section of AIEE and a member of the International Conference on Large Electric Systems. He served on the AIEE Power Generation Committee (1947-50) and System Engineering Committee (1949-52.)

W. R. Johnson

John Warren Kalb (AM '41, M '49), director of electrical research—engineering for the Ohio Brass Company, Barberton, Ohio, has been transferred to the grade of Fellow in the AIEE ". . . for contributions to lightning protection of electric power systems, particularly the development of the magnetic gap arrester." Mr. Kalb was born June 16, 1918, in Columbus, Ohio, and received a B.S. degree in electrical engineering from Swarthmore College in 1940. Early in his career, he was the co-inventor and responsible for the development of the General Electric (GE) distribution-class expulsion arrester. He conceived and developed the magnetic gap element of GE and, later, of the Ohio Brass station arresters. Thus, he invented the first two magnetic gaps in modern arresters. He worked for GE during 1941-49, beginning in the Lightning Arrester Research Section at Pittsfield. Here he received the GE Coffin Award for his invention. Following 2 years as field engineer on a lightning and overcurrent protection study, he conceived the basic design for the gap used on their first magnetic gap station-class arrester. He began work for the Ohio Brass Company in 1949, directing the lightning arrester engineering effort until 1957, when he became director of electrical research. He invented the current-limiting gap used in their arresters, and was responsible for the size reduction of high-voltage arresters to that of associated station insulation. He has been granted 10 patents, principally on arrester gaps. Mr. Kalb is author or co-author of four AIEE technical papers and is an associate member of Sigma Xi, a member of Sigma Tau, and a registered professional engineer of the State of Massachusetts. He served on the AIEE Protective Devices Committee (1955-58).

Ohio Brass Photo

J. W. Kalb

Bell Telephone

John Meszar

John Meszar (M '49), director of switching systems development, Bell Telephone Laboratories, New York, N. Y., has been transferred to the grade of Fellow in the AIEE ". . . for contributions in the field of automatic telephone interconnecting technology." Born July 20, 1901, in Beregrakos, Hungary, Mr. Meszar came to the United States in December 1920. He began his career with the Bell Laboratories in 1922 as a technical assistant, testing and evaluating telephone switchboard circuits. He received the B.S. degree in electrical engineering from Cooper Union in 1927, at which time he became a circuit design engineer for long-distance telephone switching systems. In 1936, he was appointed a group supervisor. During the war, he was supervising instructor in the Laboratories School for War Training, organizing and teaching courses for military personnel on subjects such as radars, sonars, and gun directors. Following the war, he returned to telephone switching circuit supervision. Since June 1952, as director of switching systems development, his responsibilities have included such developments as crossbar-type long-distance switching systems, local and centralized automatic message accounting systems, and projects for telephone customer nationwide or direct distance dialing. He is the author of technical papers and some philosophical articles in the field of automatic telephony, including one which won him AIEE's first prize for the best paper in the Communication Division presented during 1950. Mr. Meszar has served on the following AIEE Committees: Communication Switching Systems (1949-58, chairman 1951-53); Communication Division (1951-60, chairman 1957-59); Joint Division Committee on Automation and Data Processing (1956-58); Award of Prizes (1956-60); Research (1956-58); Technical Operations (1957-60); and Recognition Awards (1958-61).

Jules A. Wolin

I. D. Perry

Irving Davidson Perry (AM '20, M '28, Member for Life), engineer, electric engineering department, Public Service Electric and Gas Company, Newark, N. J., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the use of microwave for utility system communication and protection." Mr. Perry was born October 4, 1896, in Union City, N. J., and attended the Newark College of Engineering, Newark, N. J. He has pioneered during the last 40 years in the development of protective relaying, especially carrier current relaying, together with associated instrumentation and control systems. From January 1915 to April 1917, he was a generating station switchboard operator for the Public Service Electric Company. He served in the U. S. Navy in World War I as a radio electrician on surface vessels, and later became radio hydroplane technician in submarine service. He made tests and conducted investigations in connection with the application of loop antennas and tube transmitters and receivers in submarines. After the war, he returned to the Public Service Electric Company and was transferred to the electrical engineering department, where he did field construction work in generating and substations. In 1920, he was loaned temporarily to the General Electric Company, where he was in charge of the installation of two 300-kva Alexanderson alternators in the Radio Corporation of America Transatlantic Radio Transmitting Station at New Brunswick, N. J. During 1922-25, he was chief designer in the switchboard shop where all switchboards for the Public Service Electric Company were designed and fabricated. In 1925, he was loaned to the Public Service Production Company as electrical field engineer. During 1926-47, he supervised control and switchboard engineering and procurement for Public Service Electric and Gas Company

switching and substations. He has worked on the application of power line carrier frequency shift equipment for remote trip, power line carrier current equipment for use with oilostatic pipe-type cables, and microwave equipment for utility system communication and protection. This included the elimination of all rotating power equipment. He is a member of the Institute of Radio Engineers and is a registered professional engineer in the State of New Jersey.

AIEE PERSONALITIES

H. P. Corwith (AM '18, F '51, Member for Life), research and engineering vice-president of the Western Union Telegraph Company for more than 10 years, has retired. He joined Western Union in 1916 as an engineering assistant. Mr. Corwith was a general traffic inspector for the telegraph company for 6 years, in charge of the training of multiplex printing telegraph operators. As a special development engineer, he established Western Union's Electronic Laboratories at Water Mill, L.I., N.Y., in 1925 for research and development of radio and electronic devices. In 1934, he was appointed engineer of electronics and continued in charge of the Water Mill Laboratory until 1943. Mr. Corwith was assistant chief engineer in charge of research for 3 years before his appointment in 1946 as director of research. His appointment as vice-president followed in July 1949.

J. E. Dingman (M '37, F '54) has been elected vice-president of the American Telephone and Telegraph Company (AT&T) and appointed chief engineer of the company. Mr. Dingman was director of operations of AT&T's long lines department for the last 3 years. He has been succeeded in that post by **C. E. Schooley** (AM '44, M '50), who was formerly vice-president in charge of operations of the Indiana Bell Telephone Company.

C. T. Evans (AM '11, F '47, Member for Life), consulting electrical engineer for Cutler-Hammer, Inc., Milwaukee, Wis., has been honored for having devoted a half century of service to the electrical industry. The occasion was the closing general luncheon of the 33rd annual convention of the National Electrical Manufacturers Association, at which Mr. Evans was presented with a 50-year award. He has spent 51 years with Cutler-Hammer and was awarded 50 patents in the motor control field.

J. F. Ferrante (AM '50, M '58) has been appointed director of research in dielectrics at the Cornell-Dubilier Electric Corporation Research Laboratory now being set up in a 70,000-square-foot modern building in Norwood, Mass. Just prior to this appointment, he served as vice-president, engineering, of the Tobe Deutschmann Corporation.

A. H. Frampton (AM '21, F '45, Member for Life) has undertaken the position of director of the Industrial Division, Hawker Siddeley Industries Ltd., London, England. He was formerly a consultant. Mr. Frampton served as an AIEE vice-president (1949-51), director (1951-52), and as a member of the Power Generation Committee (1942-49, chairman 1947-49).

J. F. Getz (AM '43) has been named manager of the newly formed Power and Switchgear Division of Automatic Control Company, St. Paul, Minn. He was formerly associated with Gould National Batteries, Inc., in Trenton, N. J.

H. H. Gnuse, Jr. (AM '34, M '46) has been appointed assistant chief power engineer of the Aluminum Company of America, Pittsburgh, Pa. He will continue his past responsibilities in directing the work of the Electrical Engineering Section of the Power Engineering Division.

The American Telephone and Telegraph Company's chief engineer, **H. R. Huntley** (AM '23, F '51, Member for Life) has retired after more than 42 years of Bell System service. Mr. Huntley joined the company in 1930, and until 1942 was responsible for handling inductive co-ordination matters with power organizations. In 1942, he became head of the Inductive Co-ordination Group of the company and later became toll transmission engineer. In 1951, he was promoted to the position of transmission engineer. In January 1956, Mr. Huntley was appointed assistant chief engineer and less than a year later was named director of the newly established Customer Products Planning Division. He was appointed chief engineer in 1957. Before this association, he worked for short periods with the Aluminum Company of America, the Allis-Chalmers Manufacturing Company, and the Wisconsin Telephone Company. He served on the AIEE Wire Communications Systems Committee (1950-58, chairman 1954-56).

M. M. Koch (AM '20, F '57), executive vice-president and director of the Public Service Company of Colorado has retired after 45 years of company service. The board of directors of the company accepted his resignation from the board and elected **L. R. Patterson** (AM '30, F '57), vice-president, a director to fill the board vacancy. For the past 12 years, Mr. Koch has been chief executive of the utility's electric operations and has served as a member of the company's board of directors since 1948. Mr. Patterson, a 36-year veteran with the company, assumed the administrative responsibilities for the company's electric operations upon Mr. Koch's retirement.

H. L. Logan (AM '19, M '28, F '43), vice-president in charge of research of the Holophane Company, Inc., was honored at a recent luncheon in the New York Engineers Club for his 40 years of loyal and outstanding accomplishments in research with the company. He has served on the AIEE Board of Examiners (1948-60).

D. A. Lupfer (AM '50) has been appointed general manager of the Materials and Ceramics Division of Gulton Industries, Inc. He was formerly a research physicist and development engineer with the General Electric Company. He has served on the AIEE Solid-State Devices Committee (1959-60).

F. L. Magee (AM '20), president of the Aluminum Company of America, was honored at the 19th annual L-in-Life Award dinner of the New York Lehigh Club, held at the University Club, New York, N. Y. He received the alumni citation for his service to Lehigh University since his graduation as an electrical engineer in 1917. At present, he serves as a corporate trustee of the university.

W. G. Matheson (AM '53), supervisor of incandescant lamp research for Sylvania Lighting Products, a division of Sylvania Electric Products Inc., has been named president of the American Vacuum Society at the 6th annual symposium held in Philadelphia, Pa. Sylvania is a subsidiary of General Telephone & Electronics Corporation.

J. D. McCrumm (AM '36, M '47), professor of electrical engineering, has been named the first Howard N. and Ada J. Eavenson professor at Swarthmore College. The new chair was created early this year under the will of the late Ada J. Eavenson, which provided for establishing and maintaining a professorship in engineering in honor of her husband, a well-known consulting civil and mining engineer before his death in 1953. From 1951-59, he served as chairman of the Division of Engineering at Swarthmore. On a leave of absence from the college last year, he spent full time in the corporate offices of Burroughs as assistant to the vice-president of research and engineering.

J. W. McNair, Jr. (AM '25), technical director of the American Standards Association, has been elected a fellow of the Standards Engineers Society. The honor was conferred on him at an awards luncheon held at Boston, Mass., in conjunction with the society's annual meeting. He was named a fellow as a result of "his long and important work in standardization in the United States and in the world," according to the citation prepared by the society. Throughout his career, his leadership, technical competence, and integrity have typified the best qualities of an outstanding standards engineer."

J. J. Molloy (AM '41) has been designated superintendent of transmission for the Cambridge Electric Light Company, Cambridge, Mass., with responsibilities for high-tension operation, construction, and maintenance.

J. J. Myers (M '53) has joined the research staff of Hoffman Electronics Corporation's Science Center in Santa Barbara, Calif., as a senior scientist. He was formerly re-

search assistant professor at the Coordinated Science Laboratory of the University of Illinois, Urbana, Ill. At Hoffman, he will be responsible for studies in industrial electronics, including data processing for railroads.

A. F. Pelster (AM '42, M '48) has been appointed vice-president, sales, of Avtron Manufacturing, Inc., and **Ruben Kazarian** (AM '40, M '56) has been named chief engineer of Avtron. Mr. Pelster, a veteran of 17 years in the aircraft and missile electrical field, was formerly vice-president in charge of aircraft product sales at Leland Electric. Mr. Kazarian had been assistant chief engineer in charge of design for high-frequency welding, brazing, and heat-treating equipment at Ohio Crankshaft.

Haraden Pratt (AM '15, F '37), former telecommunications advisor to the President, and **Harry Nyquist** (M '24, F '51), former Bell Telephone Laboratories scientist, were among those named by the Institute of Radio Engineers (IRE) to receive IRE awards in 1960. Mr. Pratt has been named to receive the 1960 Founders Award. Mr. Nyquist, a consulting engineer, will receive the 1960 Medal of Honor. In addition, the 1960 Harry Diamond Memorial Award, given to a person in Government service for outstanding contributions in the field of radio or electronics as evidenced by publication in professional journals, will be presented to **K. A. Norton** (AM '41, F '56), National Bureau of Standards, Boulder, Colo.

L. T. Rader (AM '34, F '51) has been appointed vice-president of the International Telephone and Telegraph Corporation. He was formerly with the General Electric Company for more than 20 years. Dr. Rader has served on the AIEE Education Committee (1958-60) and Professional Development and Recognition Department (1959-60).

The Christopher Columbus International Award for outstanding achievement in telecommunications was presented in Genoa, Italy, to **David Sarnoff** (M '23, F '51, Member for Life), chairman of the board of the Radio Corporation of America (RCA) and two other RCA executives. Brigadier General Sarnoff and **E. W. Engstrom** (F '49), senior executive vice-president of RCA, received the award in person. **V. K. Zworykin** (M '22 F '45, Member for Life), honorary vice-president of RCA, was honored in absentia. The presentation was made by President Giovanni Gronchi of Italy at the closing session of the 7th International Congress on Communications. Dr. Engstrom now serves on the Hoover Medal Board of Award (1957-63). Dr. Zworykin was the Lamme Medalist of 1948 and the Edison Medalist of 1952.

H. H. Schwager (AM '50, M '56), manager of engineering for the Schwager-Wood Corporation of Portland, Oreg., has joined Engineering & Marketing Associates, Inc., of Portland.

H. P. Sleeman (AM '25), formerly electrical engineer, R. Thomas & Sons Company, Lisbon, Ohio, has accepted position as chief engineer of the Porcelain Insulator Corporation, Lima, N. Y., a subsidiary of the Joslyn Manufacturing and Supply Company.

G. E. Thurman (AFFIL '53) has been appointed manager of sales promotions of the Southern Electrical Company of Chattanooga, Tenn.

O. G. Villard, Jr. (AM '42), senior professor of Stanford University's Radio Propagation Laboratory, has been elected to the board of directors of Applied Technology, Inc., Palo Alto, Calif.

H. P. Westman (M '46), manager of technical publications, International Telephone and Telegraph Corporation, was made a Fellow of the Standards Engineers Society at its 8th annual meeting. Mr. Westman was cited for his work on standardization during the last 30 years. He has served on the AIEE Telegraph Systems Committee (1951-60).

W. P. Wills (M '42) has been promoted to technical advisor to the director of engineering, Brown Instrument Division, Minneapolis-Honeywell Regulator Company, Philadelphia, Pa. Mr. Wills was formerly research director of the division.

Telegraph Engineer Honored

THE F. S. D'HUMY AWARD was presented to H. F. Wilder (M '45), assistant to the applied electronics engineer, engineering department, Western Union Telegraph Company, for important telegraph engineering contributions. Mr. Wilder *(left)* was introduced at the award ceremonies by H. P. Corwith (AM '18, F '51), Western Union research and engineering vice-president *(center)*. Ray Hoover (M '44), Western Union plant vice-president *(right)*, stated that Mr. Wilder's contribution in the field of engineering design to both landline and cable transmission and signal regeneration will play an important part in the company's progress.

OBITUARIES

Edward Hiram Anson (M '54, F '57), senior vice-president of Gibbs & Hill, Inc., consulting engineers, New York, N. Y., died recently at the age of 56. His achievements included responsibility for (1) design of overhead transmission and distribution systems for the electrification of the Pennsylvania Railroad between Wilmington, Del., and Washington, D.C.; (2) location, design, and supervision of the construction of 10,000 miles of rural electric distribution systems, with all the necessary substations; (3) organization and design of all power installations and utilities for the Savannah River Plant of the Atomic Energy Commission. Mr. Anson was born December 9, 1902, in AuSable Forks, N. Y.

He joined Gibbs & Hill in 1925 after he received the B.S. degree in electrical engineering from New York University. In 1927, he left the firm to work with the American Steel and Wire Company and with Jackson & Moreland, consulting engineers of Boston, Mass. He returned to Gibbs & Hill in 1931 as an assistant engineer. In 1935, he was promoted to engineer; in 1940, to assistant vice-president; to vice-president, a year later; and in 1953, to senior vice-president. He aided in postwar reconstruction for the French Supply Council and the Economic Co-operation Administration power plants in Italy and France. During 1943-45, he was president of the Gibbs & Hill affiliate in Mexico. He was a director of the firm and vice-president and director of the Foreign Industrial Equipment Corporation. Mr. Anson was a registered professional engineer in 25 states. A member of the American Institute of Consulting Engineers, he was named president in 1957. He also was a member of the American Society of Civil Engineers, the American Nuclear Society, the American Institute of Management, the American Railway Engineering Association, the Society of American Military Engineers, and the Consulting Engineers of California. In 1955, he received a Certificate of Distinction from the College of Engineering, New York University. He held membership in Tau Beta Pi and Eta Kappa Nu. He served on the AIEE Elmer A. Sperry Board of Award Committee (1957-59).

Conway Studios

E. H. Anson

Friends and associates of the late Mr. Anson have decided to underwrite and solicit funds for an Edward H. Anson Memorial to be installed in the new Guild Hall of Technology now being erected at his Alma Mater, New York University, in University Heights. Checks should be made payable to New York University, marked "Edward H. Anson memorial," and sent to F. W. Begrisch, 370 Lexington Ave., New York 17, N. Y.

Edith Clarke (AM '23, M '33, F '48, Member for Life) of Clarksville, Md., died recently. Miss Clarke had been a professor of electrical engineering at the University of Texas. She was born February 10, 1883, in Howard County, Md., received the A.B. degree from Vassar College in 1908 and the M.S. degree in 1919 from the Massachusetts Institute of Technology. In 1912-15, she was a computer for the research engineer, American Telephone and Telegraph Company. She was in charge of calculations in the transmission and protection engineering department, American Telephone and Telegraph Company during 1915-18, and in 1919-21, she was in charge of calculations in the turbine engineering department, General Electric Company. Miss Clarke was professor of physics, Constantinople Women's College, Constantinople, Turkey, in 1921-22. In 1922-45, she was employed by General Electric, where she was engaged in work on technical problems dealing with the generation and transmission of power. Miss Clarke was a member of Phi Beta Kappa. She was awarded the Northeastern District, AIEE, prize for the best paper, "Three-Phase Multiple-Conductor Circuits," published September 1933. She was also the recipient of the joint award for the AIEE national prize for the best paper in engineering practice, "Stability Limitations of Long-Distance A-C Power Transmission Systems," published in 1941. She served on the AIEE Code of Principles of Professional Conduct Committee (1950-53) and the Power Transmission and Distribution Committee (1925-27).

Cherry Logan Emerson (M '20, F '33, Member for Life), former vice-president of the Georgia Institute of Technology, died recently at the age of 71. Born in Tunnel Hill, Ga., on June 9, 1888, he was the son of William Henry Emerson, first dean of Georgia Tech. In 1908, the younger Mr. Emerson received the B.S. degree in mechanical engineering from Georgia Tech, and in 1909, the B.S. degree in electrical engineering. He took the apprenticeship course at the Westinghouse Electrical and Manufacturing Company, East Pittsburgh, Pa., in 1909-10. His duties for the company, until 1914, were largely the development of electric equipment for the requirements of the textile industry. During 1914-19, he was employed by the Duke Power Company (at that time the Southern Power Company). In 1914-17, he was textile engineer in the mill power department. During 1917-19, he was general assistant to the chief engineer. In 1919, he joined the Atlanta engineering firm of Robert & Company, Inc., and became its president in 1933. During 1938-45, he was in charge, on an architect-engineer basis, of approximately $350 million worth of Army and Navy construction done by the firm. Mr. Emerson became vice-president in charge of expansion at Georgia Tech in 1947. Under his guidance, the campus of the engineering school was more than tripled and five major buildings were added, including a multimillion-dollar electronic computer center.

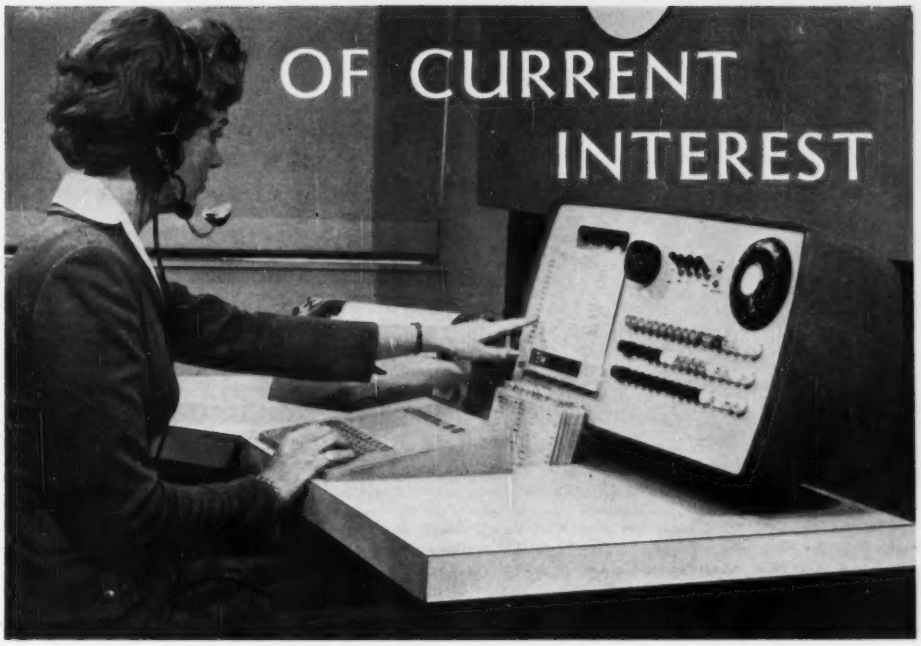
Stephen Garrett Greene (AB '49), an engineer in charge of work on government contracts in the Stromberg-Carlson Company's telecommunications engineering department, Rochester, N. Y., died recently at the age of 37. A native of Washington, D. C., he was born November 9, 1922. He received a B.S. degree in electrical engineering in June 1948 from Penn State University.

Cyril Nathaniel Hoyler (M '51), manager of technical relations of the Radio Corporation of America (RCA) Laboratories in Princeton, N. J., died recently at the age of 54. Born in Edmonton, Alta., Canada, on August 8, 1905, he taught for 2 years in the rural schools of Canada before coming to the United States to attend Moravian College, Bethlehem, Pa. He was graduated from Moravian in 1928 with the B.S. degree. In 1935, he received the M.S. degree in physics from Lehigh University, and was awarded an electrical engineering degree by Lehigh in 1957. In 1958, Moravian College conferred upon him its Comenius Award as a distinguished alumnus. Between 1929 and 1941, he was successively instructor, professor, and head of the physics department of Moravian College. He joined RCA in 1941 as a member of the technical staff at Camden, N. J. In 1942, he transferred to the newly formed RCA Laboratories in Princeton, where he became administrative assistant in 1945. He was appointed manager of technical relations in 1952. He was a senior member of the Institute of Radio Engineers and a member of Sigma Xi. He served on the AIEE Periodicals and Transactions Committee (1957-58).

John Coleman Jones (AM '36, M '37, F '48), general superintendent for the Pacific Power and Light Company, Portland, Oreg., died recently. He was born October 11, 1900, at Greenville, Texas, and graduated from the University of Texas with the B.S. degree in electrical engineering in 1921. In 1923, he received the M.S. degree in electrical engineering from the Massachusetts Institute of Technology. During 1923-26, he was transmission engineer for the Texas Power and Light Company. In 1926-35, he was transmission engineer for the Florida Power and Light Company, and in 1935-49 became superintendent of transmission for the company. He was named assistant general superintendent for the Pacific Power and Light Company in 1949, and was appointed general superintendent in 1951. Mr. Jones was a registered professional engineer in the State of Florida, a past president of the Florida Section, AIEE, a member of the Electrical Equipment Committee of the Edison Electric Institute, and served on the AIEE System Engineering Committee (1950-53).

William Karl McQuown (M '21), retired electrical engineer of the Western Union Telegraph Company, died recently at the age of 76. He was born May 30, 1883, at Winchester, Ill.

Austin Phelps Palmer (AM '39, Member for Life), a retired electrical engineer, died recently at the age of 75. He was born June 4, 1884, in Brooklyn, N. Y., and graduated in 1906 from Columbia University with an electrical engineering degree. In 1916, he was employed by the Interborough Rapid Transit Company as a draughtsman and later an assistant engineer. Mr. Palmer helped construct the substation on White Plains Road, N. Y. During 1917-18, he was an electrical draughtsman at the Brooklyn Navy Yard, and in 1918, worked for the Sperry Gyroscope Company, Brooklyn, N. Y. In 1921-30, he wrote articles for magazines on electrical subjects.



ELECTRONIC reservations system, known as SABRE, *developed by IBM for American Airlines, eventually will link more than 1,000 reservation desks in 61 cities to a central computer in the New York area. By pushing a few buttons, an agent, such as the one shown, can get instant answers on information pertaining to any flight, including a complete record of each passenger's name, telephone number, and related data.*

SABRE Cuts Airline Reservation Time

A COMPLETELY AUTOMATIC, centralized, electronic airlines reservations system known as SABRE has been developed by International Business Machines Corporation (IBM) for American Airlines after 6 years of joint research.

The system will handle all functions and procedures associated with the sale, confirmation, and control of an air travel reservation, from the time a customer calls for information on a flight to the time he arrives at his final destination.

SABRE—which has been designated the IBM *9090* by that company—puts in one central location, instantly available to more than 1,100 of American's reservation desks in 61 cities, the complete up-to-the-second account of all scheduled American flights, the seats already reserved on them, and the seats that are not reserved. SABRE also maintains a complete record of each reservation including the passenger's name, telephone number, and itinerary.

These details and other necessary data change from second to second as new reservations are made and previous reservations altered. These additions and changes are recorded in the magnetic memories of the computing center.

Installation of the SABRE system—which will be able to store more than 600 million characters and to handle more than 7,500 complete airline reservations per hour—will begin in late 1961 and most of the cities served by American will be linked to the computing center by the end of 1962. The center, to be located in the New York metropolitan area, will be linked with other cities by over 10,400 miles of leased telephone lines.

Benefits of System

The airline customers will benefit in the following ways:

1. The customer now has to wait while the agent examines the availability of space on the airplane. With the system now in effect, this procedure, at times, takes many minutes. With the new system, the waiting time will be reduced to seconds.

2. Clerical errors, resulting in inconvenience to customers, will be virtually eliminated, because the records will be kept in the "memory" of the machine, rather than on hand-written cards.

3. More airline seats will be available to the customer because SABRE offers all seats for all flights instantly on a first-come, first-served basis to all cities served by American.

4. SABRE eliminates the inconvenience to customers that results when the airline, through error, sells more seats than are available.

5. SABRE reduces the time customers remain on the waiting list for flights by making cancelled airline space available without delay to the waiting list for resale.

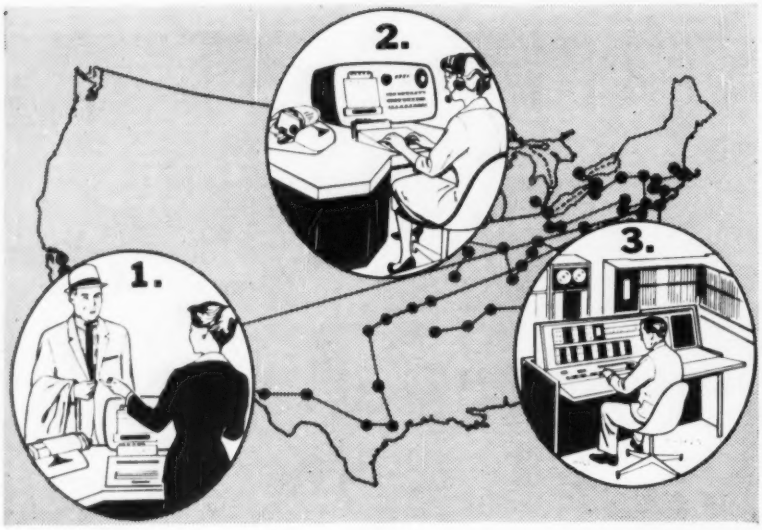
On a given day, the airline may have as many as a million passenger reservations records on file under the present system and average time required to complete the processing of a reservations transaction with its complex behind-the-scenes filing procedures is 45 minutes. SABRE will do the same job in an average of 3 seconds.

SABRE also handles special arrangements for passengers, such as a request for a car rental or space on a connecting flight. It will automatically answer requests for space from other airlines through established teletypewriter circuits.

Also, the advanced electronic system will automatically remind agents at various locations to advise their scheduled passengers of any changes affecting them, advise agents to check on passengers who have not picked up their tickets within the time limit, maintain and process waiting lists of passengers desiring space on fully booked flights, supply fare quotations for most flights, and supply information on arrival and departure time for the current day's flights.

The IBM *9090* will assist in processing: 85,000 daily phone calls; 30,000 daily requests for fare quotations; 40,000 daily passenger reservations; 30,000 daily queries

Support the New United Engineering Center



ELECTRONIC PROCESSING SYSTEM cuts reservation time to 3 seconds. (1) Los Angeles—Passenger books flight for New York with Chicago stopover. IBM system takes seconds to check availability of space and confirm reservation with central processing unit in New York. Passenger's name and itinerary are then registered electronically in central computer. (2) Chicago—Passenger decides to extend Chicago stopover. Agent queries computer, and receives complete passenger record and report on alternate space available within seconds. Agent instructs computer to make new reservation and change passenger record. (3) New York—Computer in New York stores information from 1,000 reservation desks for every seat in the airlines system.

to and from other airlines regarding seat space; 20,000 daily ticket sales.

In addition, the system will be able to prepare special reports on passenger traffic, and it can be expanded to handle air cargo inventories and routings.

Typical Transaction

Passengers' requests for reservations and other flight information are entered through the console in the local office and transmitted to the central computing center in the New York area.

The computers respond through signal lights on the console indicating seats available.

Passengers select a flight from those available and the reservation agent presses a button on the console to confirm the flight chosen. As the seat is confirmed, the computer automatically subtracts that seat from the number available for future sale.

The agent uses the console keyboard to record the passenger's name, telephone number, itinerary, and related information in the computer. There all the information becomes a part of the record of the passenger's flight until computed or cancelled.

The entire transaction is also recorded on the printer of the console, providing the agent with quick visual confirmation of all data he puts into the computer.

Electronic Watchdog Sees All, Hears All, Gives Industrial Plants 100% Protection

USING electronic eyes and ears linked to an automated nerve center, a plant protection system recently demonstrated by Minneapolis-Honeywell Regulator Company "not only can perform all the policing duties now handled by a staff of human guards in an industrial setup, but can perform them better," J. E. Haines, company vice-president, said.

He stated that the system would afford 100% protection for an entire building or factory operation, even one sprawled over many acres with entrances miles apart.

With the electronic watchdog, a single human guard—seated at a master control center—can: (1) maintain constant surveillance, (2) immediately detect fires, (3) keep an eye on all entrances by means of closed-circuit television and converse over a 2-way intercom system with anyone seeking admittance, (4) determine when any unauthorized person tries to sneak into the grounds, (5) detect a sneak-thief who might conceal himself in a room in the building and try to rifle a safe or file cabinet after the building is closed, and (6) perform other policing activities.

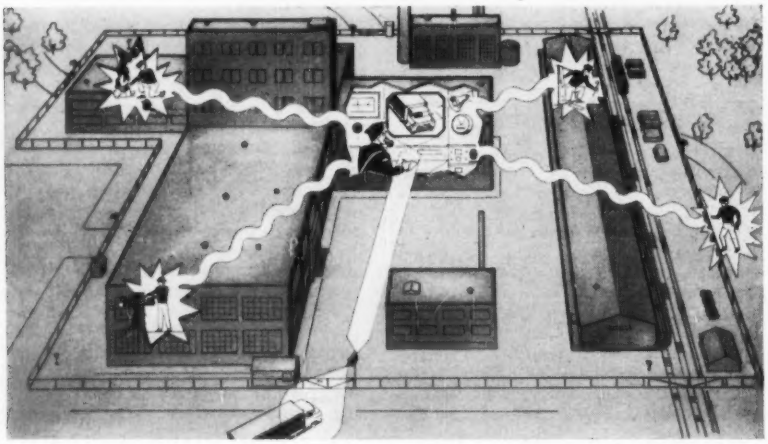
If the guard at the control center is overpowered by an intruder or collapses from illness, a built-in safeguard automatically flashes a warning to police headquarters in the area.

The system consists of a network of remotely located electronic detection devices tied into a master control panel.

These include a number of new electronic developments, such as noise and motion detectors and an electronic fence which the company says "really works." Also included are more conventional devices, such as television cameras at entrances, magnetic switches that unlock gates from the master control center, fire detectors, and holdup alarm switches.

While some of these devices previously have been available as separate units, it was pointed out that the new system introduces for the first time the concept of integrating such devices under centralized control.

Mr. Haines estimated that widespread



PROTECTION SYSTEM: Automation techniques have been applied to the probelm of protecting buildings against intrusion, fire, and other forms of security violations. This artist's conception shows how the new Minneapolis-Honeywell centralized control system allows a single guard to supervise a complete building security system from one location. Company officials said that the new integrated security system makes it possible for industrial management to reduce expenditures for plant protection by 40% and increase efficiency of its security force by 90%.

NERVE CENTER of a new building protection and security system designed by Minneapolis-Honeywell Regulator Company is this centralized console (*above, left*). With it, a single guard can supervise an entire building security system, thus performing functions that previously required a large number of guards stationed throughout a building or factory area. In a typical installation, the console is surrounded by subsystem panels that enable the guard to identify at a glance the specific area in the building in which a fire, intrusion, or equipment failure exists. *Above right:* Detection devices to be used with the new integrated building protection and security system. Included are fire- and smoke-detector heads, tamper-proof magnetic switches for windows, electronic noise and motion detectors, capacitance-type electronic fencing, and many others. Any of the devices can be tied in with the new system's centralized control console. In all instances of alarm, a guard at the console receives both an audible alarm (horn, buzzer, bell, etc.) and visual warning (a push-button switch lights up) of trouble.

use of the new system would reduce by 40% the $250 million spent annually by American industry for plant protection.

"In addition," he said, "this automated security system provides 100% plant security at all times, compared with an estimated 10% over-all effectiveness of a guard making his rounds in a large industrial building.

The annual cost of maintaining a continuous guard post is approximately $24,000. A study made recently by Westinghouse showed that use of the new automated system could reduce guard salaries alone by 50%.

How the System Works

The new system is custom-built to meet requirements of different plants and different buildings; the centralized control console serves as a basic "building block," to which subsystem panels are added to incorporate functions as desired.

When any type of security violation occurs, the guard at the main control panel receives an audible signal (by horn, bell, buzzer, etc.) and also visual alarm (by lighted switches).

To identify the particular trouble area, the guard then looks to an adjoining subsystem panel (available for fire, intrusion, equipment failure, security fencing, etc.). Each subsystem panel contains indicating lights that tell the guard at a glance the particular area in the building where an emergency exists. The panels can include a graphic diagram of the layout of the building or plant.

The subsystem panel for intrusion alarm also features a 2-way intercommunications unit which enables the guard to listen in and—if desired—speak with the person in the violated area.

The console television screen is used in conjunction with remotely-located television cameras to provide authorized entry at various plant gates. Whenever a truck driver, for example, seeks admittance, he pushes a button outside the gate to notify the guard of his presence.

The guard pushes a button to turn on the television camera and then sees the visitor's image on the console screen. He also can converse with the driver over the system's 2-way intercommunications system.

Once he verifies the person's identity and purpose of his visit, the guard pushes a button to open the gate. If desired, he then can continue to follow the truck (lens adjustments for the remote television camera are made from the console) to make certain it goes to its authorized destination.

A wide range of intrusion and fire detection devices can be used. Among conventional devices are fixed temperature-rate-of-rise fire-detector heads, smoke sensors, magnetic switches and detection tape for windows, pressure-sensitive mats, holdup alarm switches, etc.

In addition, the company has developed a number of new devices to prevent unauthorized entry, including electronic noise and motion detectors. Through use of speakers mounted in critical areas of a building, above-normal noise is detected and an alarm sounded at the guard console.

Motion is detected electronically with two new systems. The first is called the Vitronic Eye and may be used to detect motion in both indoor and outdoor lighted areas. Whenever the light pattern between a transmitter and amplifier (which may be located 2,000 feet apart) is disturbed, an alarm signal is energized, sounding an alarm at the console.

The second electronic motion detector is called the Sone-Sentry and features use of an audible signal continuously sent into a closed area. A receiver located in the room is tuned to the resulting wave pattern. Any motion in the area disturbs the signal and triggers an identifying buzzer and alarm light at the central panel.

Honeywell also has developed a new capacitance-type circuit for use with security fences. The electronic fence system is designed to detect the presence of any human being who approaches within 3 feet of the fence.

Use of a built-in compensator overcomes a problem found previously with electronic fences. The compensator prevents false alarms resulting from contact being made with the fence by birds, blowing paper, growing weeds, rain, sleet, snow and wind.

Similar capacitance-type devices also can be used with the new system to protect such top security items as cabinets, military files, safes, etc.

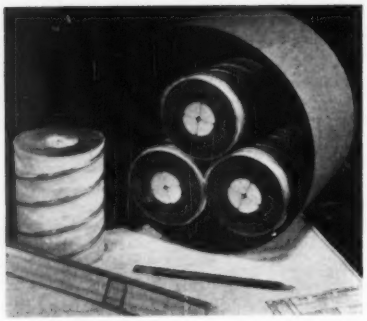
A unique 2-wire network is used to provide centralized control over as many building protection functions as desired. The number of functions that can be carried over the 2-wire system is virtually unlimited.

A single pair of wires can carry audio signals up to 3 miles and alarm signals up to 20 miles. Additional distance may be obtained through use of a simple line amplifier.

If electric power fails or is turned off by an intruder, operation of the system is automatically switched to batteries or stand-by generators.

345,000-Volt Cable To Be Used in Testing Program

The first 345,000-volt underground power cable manufactured in America was delivered recently to the Cornell University campus in Ithaca, N. Y. Manufactured in the Paterson, N. J., plant of The



◄ **345,000-volt Oilostatic cable, developed by Okonite, will be installed in a 10-inch steel pipe filled with oil and will be operated at 200 psi oil pressure. The cable has a 2,000-MCM segmental conductor with conductor shielding. Over a 1.035-inch wall of oil-impregnated paper insulation there is a series of copper, Mylar, and Dacron tapes. The assembly is finally bound with a D-shaped brass armor wire to protect the cable and aid in pulling. The cable is 4.02 inches in diameter and weighs approximately 12 pounds per foot. In normal service three cables would be pulled into the welded steel pipe.**

Okonite Company, a subsidiary of Kennecott Copper Corporation, this is one of a group of cables being supplied by four major manufacturers for a co-operative testing program with the country's largest utilities. A committee of the Associated Edison Illuminating Companies and the Edison Electric Institute is co-ordinating the program with Cornell's electrical engineering staff.

The new cable, with a 2,000-MCM segmented copper conductor, will be capable of transmitting 500,000 kva which is equivalent to the entire capacity of a large, modern generating station. It could supply the needs of over three-quarters of a million homes.

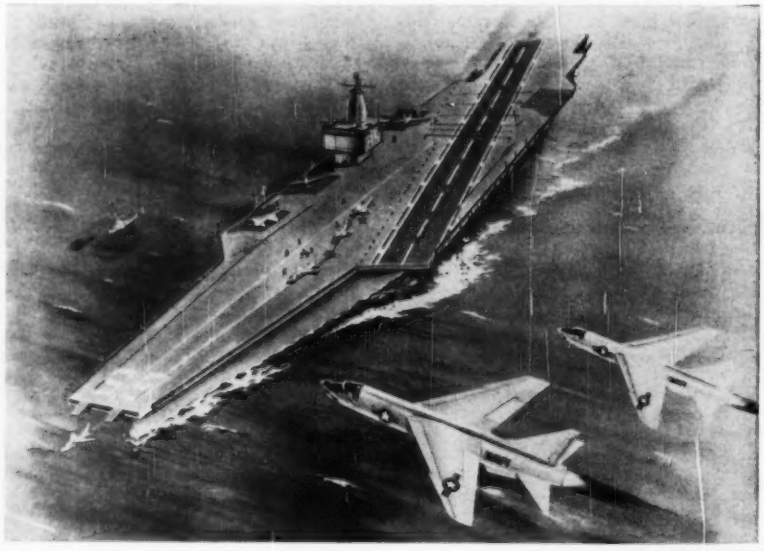
The cable is similar in basic design to the pioneer 230,000-volt Oilostatic cable which Okonite designed for the Cubatao Power Station in Sao Paulo, Brazil, and which was installed over 5 years ago. The new cable, over 4 inches in diameter and weighing close to 12 pounds a foot, will be pulled into a 10-inch diameter steel pipe filled with oil and maintained at 200 psi pressure. Since the test section is single phase, two lengths each approximately 380 feet long will be pulled into the pipe and connected by a 160-foot loop. The installation will take place in Cornell's new cable research facility, where all the cables will undergo a long series of tests under simulated service conditions.

The 345,000-volt cable is designed with a low-loss insulation developed as a result of a 4-year development program. Over 31 varieties of paper from seven suppliers were evaluated in 550 model cables. These papers differed in chemical nature and ranged through source of pulp, manufacturing process, density, and thickness. Most were cellulose in nature, but some were made from synthetics like Dacron, acetylated kraft, and glass.

Similarly, numerous petroleum and synthetic oils and treatments of these oils were evaluated in laboratory tests, in model cables, and, finally, in pilot cables. Other components also were included in these studies.

It is expected that the test program will continue for at least 3 years under the supervision of Prof. J. L. Rosson of Cornell's high-voltage laboratory.

Nuclear Propulsion Plant for Atomic-Powered Aircraft Carrier



Westinghouse Photo

ARTIST'S SKETCH shows the U.S. Navy's nuclear-powered aircraft carrier, the USS *Enterprise*, CVA(N)65, which will represent the most modern of a long series of attack carriers, starting with the USS *Langley* in 1922. Westinghouse Electric Corporation is operating the land-based prototype nuclear power plant for the carrier at the Naval Reactors Facility near Idaho Falls, Idaho, under contract with the Atomic Energy Commission (AEC). Actual design of the nuclear portion of the propulsion plant was carried on by Westinghouse under the direction of and in technical co-operation with the Naval Reactors Branch, AEC, at the Bettis Laboratory near Pittsburgh, Pa., which Westinghouse operates for the AEC. In addition to the nuclear plant, Westinghouse has a $3 million contract to design and build four giant deck-edge elevators, each of which will be capable of lifting a 40-ton plane from hangar to flight deck in a matter of 14 seconds. One of the more important features of the carrier will be almost unlimited steaming endurance at high speed. Operational flexibility will be increased also as a result of this capability since high speeds can be maintained without regard to conserving fuel oil. Offensive and defensive capabilities will be improved and replenishment requirements greatly reduced. The aviation fuel supply will be almost double that of the USS *Forrestal*, and an additional 4,000 square feet of flight deck space will permit operation of additional and larger aircraft. The carrier will be able to operate more efficiently during unfavorable weather conditions. The nuclear-powered carrier will not require smokestacks or "up-takes" to carry smoke from her boilers.

"Fishing" for Radioactivity

Fish and small game specimens, as well as samples of rain water, air, soil, milk, and vegetation will be collected and analyzed as part of the Nuclear Power Reactor Program of the Philadelphia Electric Company.

The samples will be obtained from the vicinity of the company's reactor site at Peach Bottom, Pa., and analyzed for radioactivity.

This important phase of the project known as an Environmental Radioactivity Survey, will be conducted by the Nuclear Science and Engineering Corporation (NSEC) of Pittsburgh. NSEC's scientists have perfected special analytical techniques for this work and are screening hundreds of samples yearly from all parts of the world.

NSEC vice-president and noted radiobiologist, Dr. Abraham Edelmann, states: "Even though the radiation levels are certain to be normal for this general area, it is necessary to determine precisely what they are before the reactor is placed in operation.

In this way, radioactivity baselines are established and any increases in radioactivity after the reactor is in operation can be readily detected. If increases should ever occur corrective measures can be taken before the radioactivity reaches hazardous levels."

Monitoring will be done before and after the power plant is in operation. Samples will be periodically collected from specially constructed monitoring stations

by trained technicians who will occasionally do a little hunting and fishing to complete the sample series.

New Infrared Device Detects Distant ICBMs

A new type of infrared detector, so sensitive that it can track space satellites and detect intercontinental ballistic missiles at "extreme" distances, was announced recently by Hughes Aircraft Company.

Dr. R. M. Talley, manager of the infrared laboratory of Hughes' Santa Barbara (Calif.) Research Center, said the device, a copper-doped germanium crystal that operates at the temperature of liquid hydrogen, is six times as sensitive as other existing detectors in the 8- to 25-micron range.

"Laboratory tests show that the new infrared detector responds in microseconds to very small temperature changes and makes it possible to detect targets at extreme distances," Dr. Talley said. "The short time constant of the detector recommends it for use in high speed surveillance systems."

To make the detector useful for military equipment, the Santa Barbara Research Center has developed a Joule-Thomson cryostat that operates with hydrogen gas and liquid nitrogen. This cooling technique makes it possible to design simpler and more rugged equipment than can be done under the current practice of using liquid helium cooling in a double vacuum container.

Radio Station Operates Completely on Tape

Radio station KXOL, Forth Worth, Texas, is now operating completely on tape for broadcasting purposes, using Collins Radio Company's Automatic Tape Control equipment.

Heart of the Automatic Tape Control is the tape cartridge, a plastic package in which the Mylar tape is both contained and played. The cartridges are loaded with tapes varying in time lengths of from 30 seconds to 31 minutes. KXOL maintains over 600 cartridges in its operation with the bulk of the cartridges of 1-minute duration and the rest of 3½-minute duration.

When the cartridge is to be used, it is inserted in the playback mechanism, a button is pushed and the message and/or the music is on the air, on cue, with no manual threading or cueing. Following the message or music, the tape automatically re-cues itself. KXOL uses four playback units for broadcasting and one combination record/playback unit for recording.

At the Fort Worth station, the playback units are automatically controlled by switches on the audio console; however, many wiring arrangements are possible with the Collins equipment.

KXOL uses a 4-sided tape storage cabinet, which by swiveling places over 600 tape cartridges within easy reach of the operator.

Because the tape is enclosed in a cartridge, there is no tape deterioration due to handling and playing. Its longer resultant life plus its unlimited reuseability is expected to save a considerable amount of money.

Black Glass for Enclosing Semiconductor Devices

A black glass that is impervious to light has been developed by Corning Glass Works for enclosure of silicon semiconductor devices.

The glass is being offered in the form of beads and cases for sealing to standard 0.017 Dumet lead wires.

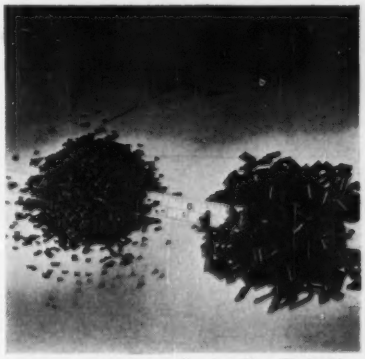
Opaqueness is a fundamental characteristic of this glass. It filters out virtually all wavelengths of the ultraviolet, visible, and near infrared spectrum. Silicon semiconductor crystals are sensitive to such radiation.

The black glass permits economies in mass production of the electronic devices, according to Corning. It eliminates the need to paint the devices and solves the costly problem of surface rub-off or scratching.

The company said the glass, designated Code 9361, has physical properties equivalent to the standard clear glass now used by diode manufacturers. The new glass has resistivity similar to the bulb glass used in standard radio tubes.

Code 9361 glass has thermal coefficient of expansion of 92 x 10^{-7} C. Softening point is about 675 C; annealing point approximately 495 C, and strain point about 455 C.

The beads and cases are precision made to tight tolerances. Bead OD is 0.053 (± 0.002) and ID is 0.023 (± 0.002). Case OD is 0.095 (± 0.002) and ID is 0.060 (± 0.002).



Corning Glass Works Photo

BLACK GLASS that is impervious to light has been developed for enclosure of silicon semiconductor devices. Corning Glass Works is offering the glass, designated Code 9361, in the form of beads and cases for sealing to standard 0.017 Dumet lead wires. The glass filters out virtually all wavelengths of the ultraviolet, visible, and near infrared spectrum. Silicon semiconductor crystals are sensitive to such radiation.

Future Meetings of Other Societies

Institute of High Fidelity Manufacturers, High Fidelity Music Show, Jan. 6-9, Shrine Exposition Hall, Los Angeles, Calif.; and Jan. 22-25, Brooks Hall, Civic Center, San Francisco, Calif. Institute of High Fidelity Manufacturers, 125 E. 23rd St., New York, N. Y.

SPE, 16th Annual Technical Conference, Jan. 12-15, Conrad Hilton Hotel, Chicago, Ill. SPE, 65 Prospect St., Stamford, Conn.

National Fire Protection Association, Committee Meetings, Jan. 18-22, Hotel Manhattan, New York, N. Y.

Electronic Representatives Association, Convention, Jan. 21-23, Edgewater Beach Hotel, Chicago, Ill. ERA, 600 S. Michigan Ave., Chicago, Ill.

Hydraulic Institute, Jan. 25-27. The Homestead, Hot Springs, Va. Hydraulic Institute, 122 E. 42nd St., New York, N. Y.

IAS, 28th Annual Meeting, Jan. 25-28, Hotel Astor, New York, N. Y. IAS, 2 E. 64th St., New York, N. Y.

11th Plant Maintenance & Engineering Conference & Show, Jan. 25-28, Convention Hall, Philadelphia, Pa. Clapp & Poliak, Inc., 341 Madison Ave., New York 17, N. Y.

ISA, Instrument-Automation Conference and Exhibit, Feb. 1-4, Rice Hotel, Houston, Texas. ISA, 313 Sixth Ave., Pittsburgh, Pa.

ASTM, Committee Week, Feb. 1-5, Sherman Hotel, Chicago, Ill.

AIME, Annual Meeting, Feb. 14-18, Hotel Statler and Hotel McAlpin, New York, N. Y. AIME, 29 W. 39 St., New York 18, N. Y.

First National Symposium on Nondestructive Testing of Aircraft and Missile Components, Feb. 16-18, Hilton Hotel, San Antonio, Texas. Sponsored by Southwest Section Society for Nondestructive Testing and Southwest Research Institute. W. E. Cory, SRI, 8500 Culebra Rd., San Antonio, Texas.

Overseas

IEE, Discussion Meetings on Reliability and Maintenance of Digital Computer Systems, Jan. 20-21. IEE, Savoy Place, London, WC 2, England. IEE same.

Conference on Automatic Computing and Data Processing in Australia, May 24-27, Univ. of Sydney and Univ. of New South Wales, Australia. *Deadline for paper summaries:* Feb. 1. C.H.D. Harper, Australian Natl. Committee on Computation and Automatic Control, The Institution of Engineers, Science House, 157 Gloucester St., Sydney, Australia.

3rd International Electronic Parts Show, Feb. 19-23, Parc des Expositions de la Porte de Versailles, Paris, France. National Federation of French Electronic Industries (FNIE), 23 Rue de Lübeck, Paris 16, France.

Industrial Latin American Partnership Exhibition, Apr. 1960-Oct. 1961, Parque Ibirapuera, Sao Paulo, Brazil. E. L. Neville, ILAPE Representative, 60 E. 42 St., New York 17, N. Y.

New Electric Power Generation System Based on MHD Principle

Ten leading power companies have joined with Avco Corporation in a research project which could revolutionize the nation's electric power industry and effect a 25% increase in operating efficiency, it was announced recently by the participating companies.

Key to the project is elimination of most of the turbine-generators in today's conventional power generation cycle.

The new power system is based on the scientific principle of magnetohydrodynamics (MHD). A small experimental laboratory device, utilizing the MHD principle to generate electric power, is currently operating successfully at the Avco-Everett Research Laboratory in Everett, Mass.

The utility group joining with Avco includes: Appalachian Power Company, Roanoke, Va.; Central Illinois Light Company, Peoria, Ill.; The Dayton Power and Light Company, Dayton, Ohio; Illinois Power Company, Decatur, Ill.; Indiana & Michigan Electric Company, Fort Wayne, Ind.; Indianapolis Power and Light Company, Indianapolis, Ind.; Kansas City Power & Light Company, Kansas City, Mo.; Louisville Gas and Electric Company, Louisville, Ky.; Ohio Power Company, Canton, Ohio; and Union Electric Company, St. Louis, Mo. (Appalachian, Indiana & Michigan, and Ohio Power are subsidiary companies of American Electric Power Company.)

The 10-company utility group will be represented by American Electric Power Service Corporation, as agent, in carrying out the joint research project with Avco.

At present, two types of power plants are being studied in conjunction with magnetohydrodynamic generators. One would use a coal-fired furnace to heat and ionize the gas entering the magnetic field of the MHD generator; the other would use a nuclear reactor for the same purpose.

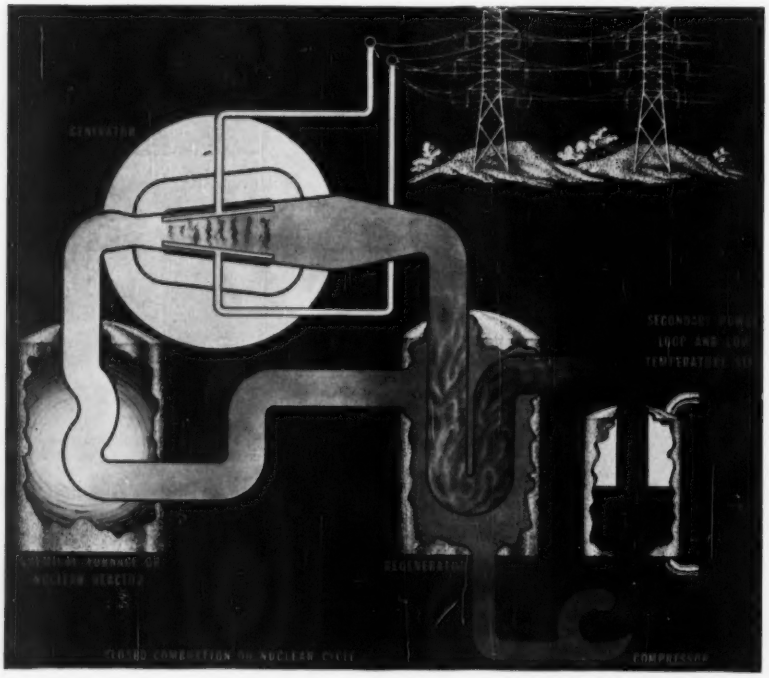
At high-enough temperatures, gases become ionized; that is, the atoms comprising the gas tend to lose one or more of the electrons which circle the atomic nucleus. A normal atom is electrically neutral—the negative charges of the planetary electrons are balanced by the positive-charges of the protons in the nucleus. When electrons are lost, the atom becomes a positively-charged ion. The free electrons, naturally, maintain their negative charges.

An ionized gas will conduct electricity. An ionized gas passing through a magnetic field will generate electricity.

Thus, MHD unites two fields which have been intensively studied for many years: gas dynamics and electromagnetic theory. There are a wealth of offspring possible from this mating, including applications for space propulsion, missile and satellite re-entry, and controlled nuclear fusion power.

In an experimental laboratory device utilizing the MHD principle, the Avco-Everett Research Laboratory has recently attained a 10-kw power output. This achievement constitutes a first step in putting experimental theory into engineering practice. The work is under the immediate direction of Dr. R. J. Rosa.

Incidentally, due to a semantic hitch in engineering jargon, gases are often referred to as "compressible fluids." Hence the *hydro*-dynamics of MHD and the gas used in the MHD generators described below is often referred to as the working "fluid."



SYSTEM CHART shows magnetohydrodynamic commercial power generation cycle. Chemical furnace or nuclear reactor (lower left) heats and ionizes working gas, which then flows through a magnetic field in the MHD generator. Direct current is tapped off the ionized gas by means of electrodes in the generator. Gas is then cooled in regenerator and heat sink, compressed and then preheated in regenerator prior to re-entering furnace for heating and ionization. Feasibility of this method of power generation on a commercial scale will be studied under a joint research program now being undertaken by Avco Corporation and 10 leading power companies.

New Award Established by NSPE

An Industrial Professional Development Award will be presented annually by the National Society of Professional Engineers (NSPE) to the industrial employer of engineering personnel which has made an outstanding contribution to the advancement and improvement of the engineering profession through its employment practices.

The first award will be presented by the NSPE president at the annual meeting of the group in June 1960, in Boston, Mass.

The 2-fold purpose of the award is to "give adequate recognition to the firm which has demonstrated the application of forward-looking engineering employment practices, and to encourage industrial employers of engineering personnel to adopt progressive engineering employment practices in accord with established professional standards," H. A. Mosher, NSPE president, stated in announcing the award.

Mr. Mosher said the award was "a part of the continuing NSPE program to aid in the enlarging of opportunities for professional growth among engineers employed in industry." The National Society president added that one of the important factors in the annual award will be the "widespread dissemination of information about some of the excellent professional development programs now available to engineers in industry."

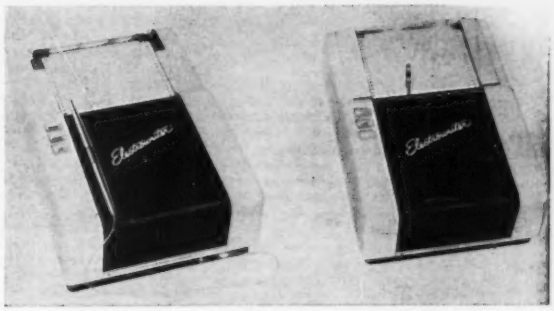
Nominations for the award will be submitted by local chapters of the NSPE. The NSPE Industrial Award Committee will make the final selection from nominations submitted by affiliated state societies.

Five professional engineers in industry have been named to serve on the Award Committee. They are: R. A. Blackburn, manager, Strategic Materials Section, Engineering and Construction Division, Koppers Company, Inc., chairman; L. J. Larson, consulting engineer, Welding Industries Group, Allis-Chalmers Manufacturing Company; W. E. Ault, manager, technical department, "Automatic" Sprinkler Corporation of America; George Steven, general manager, Worthington Corporation; and R. F. Danner, vice-president, research & development, Oklahoma Gas and Electric Company.

Among the engineering employment practices which will be considered for the

award, according to Chairman Blackburn, are those relating to registration, education and technical training, technical and professional society membership, engineers as authors, professional working conditions utilization, engineering titles, and engineer–management communications.

Further information about the Industrial Professional Development Award may be obtained from NSPS Headquarters, 2029 K St., N. W., Washington 6, D. C.



ELECTROWRITER transmitter *(left)*, and Electrowriter receiver *(right)*, produced by the Communications and Electronics Division of the Comptometer Corporation. The Electrowriter instruments transmit written messages or sketches over telephone or radio circuits.

Instruments Transmit Writing Over Telephone or Radio Circuits

"Electrowriter" instruments which transmit written messages or sketches over telephone or radio circuits have been introduced by the Comptometer Corporation, Chicago, Ill.

A. E. Carlson, president of Comptometer, said the company's Electrowriter instruments "fill the gap" which has existed in the field of instantaneous communications. The user of the Electrowriter instruments writes or draws with a pen on paper as on any note pad, and as the pen moves, the remote receiver, or receivers, instantaneously and faithfully reproduce the copy as it is written.

Any number of Electrowriter instruments, in any desired combination, any distance apart, can be interconnected. The instruments are self-contained and are fully transistorized. No extraneous power supplies are required.

The instruments can be used in conjunction with existing telephone systems as well as over radio circuits. The instruments can be attached to the telephone system normally used by plants and offices and will permit both alternate written-message and voice service. The messages between Electrowriter stations will pass through the switchboard in the same manner as telephone calls.

If a person calls a telephone extension equipped with Electrowriter "Leave Word" service, and no one answers his call, he can switch to "writing" and leave written notes for the called party at the unattended station.

The line of Electrowriter instruments include the following: (1) Model *88* transmitter; (2) Model *88* receiver; (3) Model *88* transceiver; (4) Model *89* transmitter; (5) accessories, such as winders for spooling messages, push-button selectors, dial selectors, alerting devices, telephone instruments with manual transfer key for voice/write service, and the automatic "Leave Word" service.

The Model *88* instruments feature a writing surface of 5 inches by 3½ inches. The units are 9½ inches wide, 14$\frac{5}{16}$ inches long, 5 inches high at the front and 6 inches high at the back. They weigh 30 pounds, have a power consumption of 13 watts, and use a power source of 105 to 125 volts, 50 to 60 cycles. They use either roll or fan-fold paper, plain or printed. Rolls contain 400 frames, 6 inches by 6 inches. The standard fan-fold package contains 900 forms, 6 inches by 6 inches. Packets containing 2,000 forms are also available.

The Model *88* transceiver is a single unit transmitter/receiver. When transmitting, the stylus is attached to the pen. Upon completion of the transmission, the equipment automatically switches to the receiving position.

The Model *89* transmitter is designed for special applications on wire or radio circuits. It is a portable transmitter which weighs 3½ pounds and is battery operated and transistorized. It is 6¼ inches wide by 9¼ inches long, with a front height of 1¼ inches and a rear height of 2½ inches. It provides a writing area of 3¾ inches by 2$\frac{5}{8}$ inches on continuous paper.

Museum Displays Inventions of Edison, Zworykin, Other "Firsts" in the Communications Field

A RECENT EXHIBIT, entitled "Selected Treasures of the Henry Ford Museum and Greenfield Village," at the Ford Museum in Dearborn, Mich., included the objects shown at the right as outstanding firsts in the communications field. F. R. Davis, curator of communications, holds the first radio tube patented by Dr. Lee de Forest in 1907. Other objects *(above the tube and clockwise)* are: the world's first practical typewriter, made by Remington in 1874; the first television apparatus developed by Dr. Charles Francis Jenkins in 1925, the first device to transmit and receive an image electronically; Thomas A. Edison's first mimeograph machine, patented in 1876 and forerunner of all the world's mimeograph machines and paper stencil duplicating processes; Hugo Gernsback's 1905 Telimco wireless set, the first home radio marketed in the world; and early iconescope developed by Dr. Vladimir Zworykin in 1940 which transmitted pictures electronically and made possible modern television; and Edison's first phonograph invented in 1877.

Other first inventions and memorabilia included in the museum's extensive Edison collections are the world's first motion-picture camera, invented by Edison in 1889; an experimental incandescent light produced by Edison in 1878, the year before his first successful electric light; and an experimental notebook dated 1880.

Courtesy of The Henry Ford Museum, Dearborn, Mich.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question

ADVANCES IN ELECTRONICS AND ELECTRON PHYSICS, VOLUME XI. Edited by L. Marton. Academic Press, Inc., 111 Fifth Ave., New York 3, N. Y., 1959. 523 pages, 6¼ by 9¼ inches, bound. $15. This collection of critical reviews of current developments in the field of electronics covers such areas as photoemission, parity nonconservation in weak interactions, quantum efficiency of detectors for visible and infrared radiation, automatic data processing in the physical sciences, operational amplifiers, radio telemetering, electron diffraction structure analysis and the investigation of semiconducting materials, and secondary electron emission from solids. Extensive bibliographies are included.

AIRCRAFT ELECTRICAL ENGINEERING. By G. G. Wakefield. The Macmillan Company, 60 Fifth Ave., New York 11, N. Y., 1959. 349 pages, 6½ by 10 inches, bound. $10. In this survey of varied techniques used in aircraft electrical engineering, special attention is given to the presentation of environmental characteristics and the problems of high-altitude brush wear, as well as to the cooling of electric machinery in high-speed aircraft. The aspects covered include vibration problems, d-c and a-c machinery, switchgear, aircraft batteries and their behavior on constant potential charge, electric power systems, electrical installation engineering, and system operation and installation.

APPLIED SOLAR ENERGY RESEARCH. Second edition. Published by the Association for Applied Solar Energy Research, 3424 North Central Ave., Phoenix, Ariz., 1959. 275 pages, 8½ by 11 inches, bound. $7.50. The work of laboratories and of individuals actively engaged in solar energy research is described, and a bibliographical survey is made of the field. Arrangement of the bibliography is by broad subject divisions which include such aspects as solar radiation and its effects, and the use of solar energy as heat–low temperature conversion, as heat–high temperature conversion, and as light.

AUTOMATION TODAY AND TOMORROW. By L. L. Goodman. Essential Books, 16-00 Pollitt Dr., Fairlawn, N. J., 1959, 158 pages, 5¾ by 8¾ inches, bound. $7.20. The field of automation is surveyed and some of its important aspects are described. These include sales and distribution, building design, computer control of processes, instrumentation in the process industries, processing methods and automatic assembly, industrial finishing, and inspection and testing. In addition, automation in specific industries is discussed, and an extensive bibliography is provided which includes references to books and articles covering many of the advances in automation.

ELECTRONIC SWITCHING, TIMING, AND PULSE CIRCUITS. By J. M. Pettit. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York, N. Y., 1959. 267 pages, 6½ by 9½ inches, bound. $7.50 Both phyical understanding and analytical techniques are developed in this text which is concerned with tubes and transistors used as switches to produce waveforms that may be rectangular, triangular, or a succession of short pulses. Analysis is based on the graphical representation of the tube or transistor characteristics, and approximates these by linear segments. Any group of these segments may be used during a given interval of time to permit linear circuit analysis in that interval. Vacuum tubes and transistors are treated in parallel fashion, with their similarities as well as their differences indicated.

GMELINS HANDBUCH. Eighth edition. System Nr. 5, Fluor, Ergänzungsband. 1959. 258 pages, 6¾ by 9¾ inches, paper. $36. System Nr. 15, Silicium, Teil C. 1958. 501 pages, 6¾ by 9¾ inches, paper. $67.44. System Nr. 59, Eisen, Teil D Ergänzungsband, Magnetische Werkstoffe. 580 pages, 6¾ by 9¾ inches, paper. $77.04. Published by Verlag Chemie, Weinheim, West Germany. Three new volumes have been added to this extensive reference work: (1) Fluorine: a supplementary volume covering the literature from 1926 to 1949 on the occurrence, production, physical properties, chemical reactions, and analytical determination of fluorine; (2) Silicon: an addition to the previous silicon volumes which deals specifically with the preparation, constitution, properties, and applications of the organosilicon compounds; (3) Magnetic Materials: essentially a suplement to the previous volumes on iron, this extensive treatment of the constitution and properties of ferromagnetic elements and alloys also supplements the cobalt, nickel, manganese, and chromium sections of the series. A large part is devoted to the oxide semiconductors.

HIGH-SPEED COMPUTING. By S. H. Hollingdale. The Macmillan Company, 60 Fifth Ave., New York 11, N. Y., 1959. 244 pages, 5¾ by 8¾ inches, bound. $5. The subject of computing is approached from the point of view of the user, with particular emphasis on programming. Following an elementary introduction, two British computers, the EDSAC and the DEUCE, are considered in detail, and the problems of storage and "logical design" of computing circuits are discussed. The concluding portion is concerned with applications in science and research. The Monte Carlo method, control of industrial processes by computers, and the machine translation of languages.

INFORMATION TRANSMISSION, MODULATION, AND NOISE. By Mischa Schwartz. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 461 pages, 6¼ by 9½ inches, bound. $11. A unified approach to the modern information transmission system is provided in this text which emphasizes the two fundamental limitations to the transmission of information: nonzero time response of finite bandwidth and noise. The significance of these two limitations is explored by means of a representative group of modulation systems. The topics covered include transmission through electric networks, modulation, periodic sampling and pulse modulation, noise, a comparative analysis of information-transmission systems and the statistical methods used in analyzing an information-transmission system.

INSTRUMENTATION IN SCIENTIFIC RESEARCH. by K. S. Lion. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959 324 pages, 6¼ by 9½ inches, bound. $9.50. This is a comparative study and analysis of electrical input transducers which stresses basic methods and systems used. Input transducers for mechanical, thermal, magnetic, and electrical quantities, as well as for optical and nuclear radiation are discussed. The physical mechanisms involved in the operation of each transducer are described, as are the quantitative relationships between input and output, and the range of application. The limitations, the errors, and the response to environmental influences are also considered.

IONENAUSTAUSCHER. Volume I. By F. Helfferich. Verlag Chemie GmbH, Weinheim, West Germany, 1959. 520 pages, 6½ by 9¾ inches, bound. 48 DM. This first volume of a set of three on ion exchange covers the fundamentals: theory, structure and method of action, types of ion exchangers with their constitution and properties, ion exchange membranes and packing towers, behavior in nonaqueous and mixed solutions, special types of exchangers. The succeeding volumes will deal with specific applications.

LECTURES IN THEORETICAL PHYSICS. Volume I. Edited by W. E. Brittin and L. G. Dunham. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., 1959. 414 pages, 6¼ by 9¼ inches, bound. $6. This volume contains lectures delivered at the Summer Institute for Theoretical Physics held at the University of Colorado in 1958. The lectures deal with pair production and bremsstrahlung in the field of an atom, theory of particles with zero rest-mass, strange particles and their interactions, statistical-mechanical theory of irreversible processes, multiple production of mesons and a nonlocal theory of fields, and high-energy collision theory.

THE MAGNETODYNAMICS OF CONDUCTING FLUIDS. By Daniel Bershader. Stanford University Press, Stanford, Calif., 1959. 145 pages, 6¼ by 9¼ inches, bound. $4.50. Electromagnetic theory and fluid mechanics are combined from the continuum point of view in order to discuss the physical concepts and obtain results relating to the influence of magnetic fields on wave propagation, shock tube flows, subsonic and supersonic nozzle flows, and viscuous boundary layers. Although the studies are largely analytical, some experimental results dealing with magnetohydrodynamic lift and with shock wave behavior have been added.

METALS FOR NUCLEAR REACTORS. By W. A. Maxwell. American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio, 1959. 117 pages, 6¼ by 9¼ inches, bound. $8. This basic introduction to the principles of nuclear metallurgy discusses physical principles, typical design and materials problems, effects of radiation, corrosion by liquid metals and aqueous solutions, fabricating techniques for reactor components, and testing methods.

MODERN NETWORK ANALYSIS. By F. M. Reza and S. Seely. McGraw-Hill Book Company, 330 W. 42nd St., New York 36, N. Y., 1959. 373 pages. 6¼ by 9¼ inches, bound. $10. This intermediate text is divided into three parts dealing with the fundamentals of network analysis; its applications to two ports, filters, and transmission lines; and transient response and system functions. The general properties of networks are approached in terms of the complex variable s, and network topological concepts are introduced to provide a basis for the unique selection of independent variables. Considerable attention is given to the response of networks to singularity functions as well as to the more usual excitation functions.

NOMOGRAPHY. By A. S. Levens. Second edition. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1959. 296 pages, 6¼ by 9¼ inches, bound. $8.50. This text provides a working knowledge of the basic theory and construction of charts involving straight line scales, curved scales, and combinations of the two. New chapters are presented on circular nomograms, projective transformations, and the relationship between concurrency and alignment nomograms. In addition there is a considerable expansion of the material included in the previous edition and a number of new problems and examples are introduced. An appendix includes 58 nomograms from various scientific fields.

NUCLEAR PROPULSION AND ENGINEERING FOR ENGINEERS. By D. G. Samaras. Technical Chamber of Greece, Athens, Greece, 1955. 701 pages, 7 by 9¾ inches, bound. Price not given. The principles of nuclear energy and their application to aircraft propulsion are presented. The author discusses radioactivity associated with energy release, nuclear reactions as a source of energy release, neutrons as triggers of nuclear energy release, energy release characteristics of fission, neutron dynamics in propulsion reactors, steady operation of thermal neutron homogenous reaction and other type of reactors, unsteady reactor operation and control, and nuclear energy extraction and transformation. Since the use of materials and their modes of failure are important, the author included a considerable amount of information on high-temperature materials, heat transfers, creep, thermal fatigue, corrosion, oxidation, and thermal shock. Although only unclassified or declassified data is used, much useful information is included.

PRINCIPLES OF ANALOG COMPUTATION. By G. W. Smith and R. C. Wood. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 234 pages, 6¼ by 9¼ inches, bound. $7.50. Designed for the user of analog computers, this volume presents those methods of analog computation which form the fundamental tools for the

analyst working in the field. With primary emphasis on the types of problems that can be solved, such topics are discussed as problem planning and programming, simulation of linear systems, the use of diodes in analog computations, function relays, implicit-function techniques, and arbitrary function generators.

PROGRESS IN NUCLEAR ENERGY. (METALLURGY AND FUELS, VOLUME 2.) Edited by H. M. Finniston and J. P. Howe. Pergamon Press, 122 E. 55th St., New York 22, N. Y., 1959. 653 pages, 6¼ by 9¼ inches, bound. $21. The volume is divided into two parts. Part one is an account of the metallurgical development of the various materials of specific interest to nuclear energy. In this section an attempt is made to report the experiences of various countries in respect to their development of particular fuel elements for a number of diverse reactor systems. Part two is concerned with solid-state physics and physical metallurgy.

RECENT ADVANCES IN ATMOSPHERIC ELECTRICITY. Edited by L. G. Smith. Pergamon Press, 122 E. 55th St., New York 22, N. Y., 1959. 631 pages, 7½ by 9¾ inches, bound. $17.50. Papers included in this volume constitute the proceedings of the Second Conference on Atmospheric Electricity, and deal with fair weather electricity, thunderstorm electricity, and the lightning discharge. Among the many aspects covered are recent progress in the electricity of the terrestrial atmosphere, in cloud physics, and weather modification.

TWO-WAY RADIO. By A. H. Lytel. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 291 pages, 6¼ by 9½ inches, bound. $9.50. This book is an introduction to the theory and practice of voice-modulated radio communications covering both mobile and base-station radio transmitters and receivers as well as their related test equipment. Both AM and FM transmitters and receivers are covered as are antennas, selective calling methods, power supplies, installation, and servicing. Newer types of AM such as single side band, suppressed carrier double side band, and synchronous AM are also described.

VACUUM VALVES IN PULSE TECHNIQUES. By P. A. Neeteson. Second edition. The Macmillan Company, 60 Fifth Ave., New York 11, N. Y., 1959. 195 pages, 6¼ by 9 inches, bound. $5.50. This presents methods used for determining the behavior of a network in which electron tubes are used as switches. After an introductory section on the opening and closing of switches in networks and on the principles of operational calculus, a thorough treatment of the vacuum tube as a switch is given. Then follows a discussion of multivibrators, specifically bistable, monostable, and astable vibrators. In this edition a new chapter on several types of blocking oscillators is included.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

STATISTICAL SURVEY—GENERATING CO-OPERATIVES AND MUNICIPALITIES (TID-8509). Published by the Atomic Energy Commission, this survey is available from the Office of Technical Services (OTS), Department of Commerce, Washington 25, D.C., for $1.25. This is an assessment of the feasibility of low-level power generation through the use of certain types of small-sized nuclear reactors. It includes data obtained through a questionnaire sent to more than 217 co-operative and publicly owned electric power organizations having generating capacities of 500 kw. or over. Other publications relating to the low-level power generation study, which are available from the OTS, are: TID-8508, *Task Force Evaluation Report—Small-Sized Nuclear Power Plant Program*, price $1.75; TID-8510-A, *A Brief Summary of Boiling Water Reactors in the 5- to 40-EMW Range*, price $2.75; TID-8511, *Small-Sized Organic Moderated Reactors*, price $1.25; TID-8512, *20,000-KW Organic Moderated Power Plant*, price $2.75; TID-8514, *Survey of PWR Power Plants, 10- to 30-EMW Size*, price $4.

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EIA STANDARDS. Copies of the following Electronic Industries Association (EIA) standards may be obtained through the EIA Engineering Dept., 11 W. 42nd St., New York 36, N.Y. *Land Mobile Communication FM and PM Transmitters*, RS-152-A, price 80¢ a copy; *Television Picture Area—35-mm and 16-mm Motion-Picture Film*, RS-226, price 25¢ a copy; *One-Inch Perforated Paper Tape*, RS-227, price 25¢ a copy; *Fixed, Tantalum Electrolytic Capacitors (Polarized)*, RS-228, price $1.65 a copy.

ASA STANDARD. A new standard, called *Standard Method of Measurement of Television Luminance Signal Levels*, C6.3-1959, has been approved as an American Standard and published by the American Standards Association (ASA). It describes methods of measuring the significant amplitude levels of a monochrome or color television signal, either composite or noncomposite. It consists primarily of a change in the response characteristics of the oscilloscopes to insure adequate suppression of the color subcarrier. It is also identified as an Institute of Radio Engineers (IRE) standard, 58 IRE 23. S1, replacing Part 1 of standard 50 IRE 23. S1. It is available at 60¢ a copy from the ASA, Dept. PR 108, 70 E. 45th St., New York 17, N.Y.

THE SERVO ENGINEER'S HANDBOOK. This 128-page illustrated text book is the first book devoted to servo components specifically and meets the need for a guide to the application of servomechanisms. The handbook deals with the individual components—how to use them, not how to make them. Although the basic theory is presented, the over-all treatment is practical rather than classical. There are 61 diagrams, schematics, graphs, and 65 major equations. The book contains eight chapters: Introduction to Servomechanisms; Servo Motors; Rate Generators; Synchros; Gear Trains; Servo Amplifiers; Servo-System Engineering; Environmental Testing. It is available from Daystrom Transicoil, Division of Daystrom, Inc., Montgomery County, Pa. The price is $3.

NATIONAL ELECTRICAL CODE. 1959 Edition. The following new and revised National Electrical Manufacturers Association (NEMA) Standard publications are available: AB 1-1959 *Molded Case Circuit Breakers* (40¢ per copy); BC 1-1959 *Bituminized-Fibre Conduits and Fittings* (40¢ per copy); CP1-1959 *Shunt Capacitors* (50¢ per copy); DC 4-1959 *Dial Arrangement of Warm Air Limit and Fan Controls* (20¢ per copy); DC 5-1959 *Surface-Type Electric Water Heater Controls* (20¢ per copy) DC 6-1959 *Nameplate Information, Ampere Ratings, Voltage Rating and Load Characteristics* (20¢ per copy); FU 1-1959 *Low-Voltage Cartridge Fuses* (70¢ per copy); HE 2-1959 *Electric House Heating Equipment* (30¢ per copy); HV 1-1959 *Summary of Characteristics of Apparatus Insulators* (25¢ per copy); SM 10-1959 *Piping Systems for Turbine Generator Units* ($2 per copy). Howard Michener of the NEMA staff has prepared an *Analysis* of the changes which have been approved since 1956. Price is 50¢ each. Copies of the Analysis as well as Standards are available from National Electrical Manufacturers Association, 155 E. 44th St., New York 17, N.Y.

IEC STANDARDS. Three new chapters to the International Electrotechnical Commission (IEC) Specification for Alternating-Current Circuit Breakers (56-4) have been added to the previous sections (56-1, 56-1-A, 56-2, 56-3) and made available at $4.80 a copy from American Standards Association, Department PR, 70 E. 45 St., New York 17, N.Y. The specification applies to circuit breakers for frequencies in the range 25 to 60 Hz (cps), intended for use in systems of voltage above 1,000 volts in normal service conditions. The chapters contain the following: Chapter III: Rules for Strength of Insulation—general, definitions, rules for rating, tests, appendix; Chapter IV: Rules for the Selection of Circuit Breakers for Service—general, selection of ratings for normal service conditions, selection of ratings for fault conditions, information to be given with inquiries, tenders and orders, appendix; Chapter V: Rules for the Erection and Maintenance of Circuit Breakers in Service—general, erection and maintenance.

GUIDE FOR LOADING DRY-TYPE DISTRIBUTION AND POWER TRANSFORMERS, C57.96. This guide, published by the American Standards Association as an appendix to the C57.12 series of American Standards for Power and Distribution Transformers, can be obtained at $1.35 from the American Standards Association, Dept. PR 107, 70 E. 45th St., New York 17, N.Y. The guide contains requirements, terminology, and test codes used by electric light and power companies and manufacturers of transformers; it covers general recommendations for the loading of dry-type distribution and power transformers that have insulation systems to 150 and 220 C maximum hottest-spot operating temperatures. Sections included cover basic loading conditions for normal life expectancy; loading of transformers with moderate sacrifice of life expectancy; loading of transformers having a nominal rating; supplemental cooling; basis for calculations of temperatures, loss of life, and loads; and protective devices.

DIGEST OF LITERATURE ON DIELECTRICS, Vol. 22. Published by the Conference on Electrical Insulation, National Academy of Sciences–National Research Council, this volume covers material dealing with the fundamental and applied aspects of dielectrics and dielectrical phenomena published in United States and foreign literature during 1958. It includes the following chapters: Instrumentation and Measurements, Table of Dielectric Constants, Dipole Moments and Dielectric Relaxation Times, Molecular and Ionic Interactions in Dielectrics, Conduction Phenomena in Solid Dielectrics, The Breakdown of Dielectrics, Ferroelectric and Piezoelectric Materials, Ferromagnetic Materials, Rubber and Plastic Insulation, Insulating Films, Insulating Liquids and Their Applications, Ceramic Insulation, Engineering Applications. The volume may be ordered from Printing and Publishing Office, National Academy of Sciences–National Research Council 2101 Constitution Avenue, N.W., Washington 25, D.C., for $5. A limited supply of back volumes are available for the same price.

COMMUNICATIONS - ELECTRONICS TERMINOLOGY. This book, Air Force Manual 100-39 was compiled at Maxwell Air Force Base by Air University's Research Studies Institute. The volume provides complete cross-references, as well as listings of terms, nicknames, designations, abbreviations, and definitions used in military and civilian communications and electronics, including the field of astronautics. The book is available through the Government Printing Office, Washington, D.C.

RUSSIAN TECHNICAL JOURNALS. The 1959 issues of English editions of four leading Russian journals have been translated and published by the Instrument Society of America (ISA). These include four important Soviet journals: *Measurement Techniques, Instruments and Experimental Techniques, Automation and Remote Control*, and *Industrial Laboratory*. Both 1958 and 1959 issues are available for annual subscription rates ranging from $20 to $35. For additional information write ISA, 313 Sixth Avenue, Pittsburgh 22, Pa.

Annual Index

to

ELECTRICAL ENGINEERING

for

Volume 78, 1959

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With further reference to technical program papers, if a *Digest* appears, it will be listed as (Digest of 59-000). If the essentially full text or the full text appears, it will be listed simply as (59-000).

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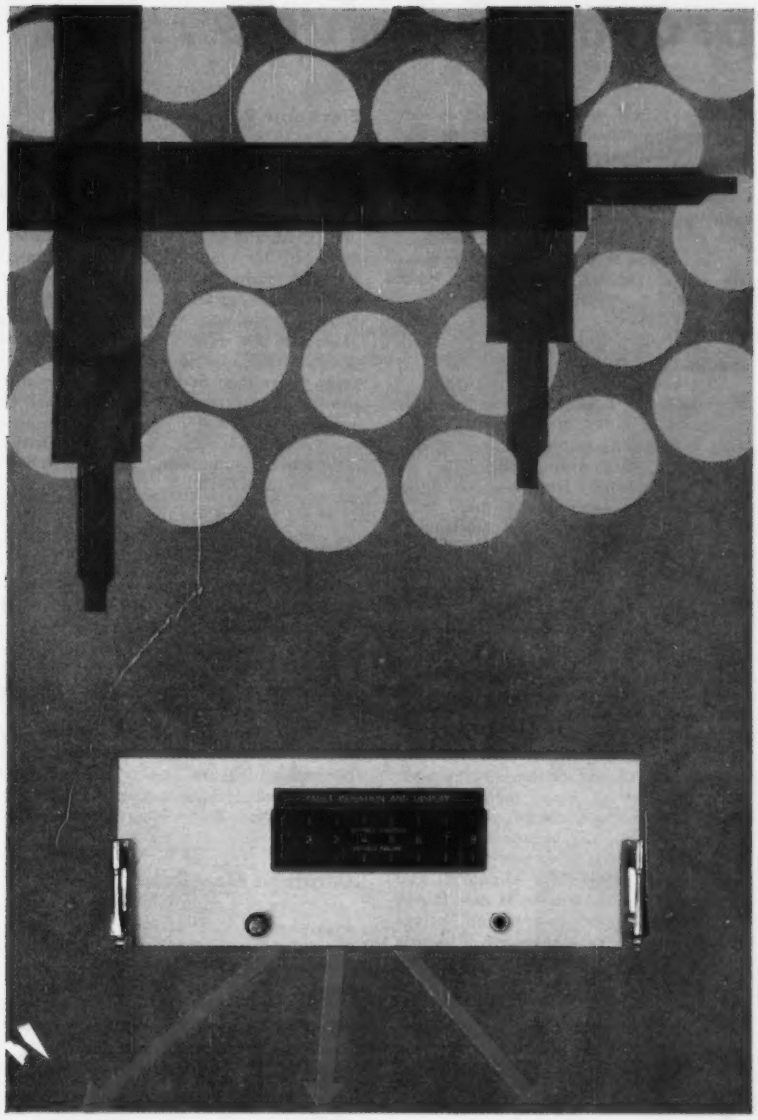
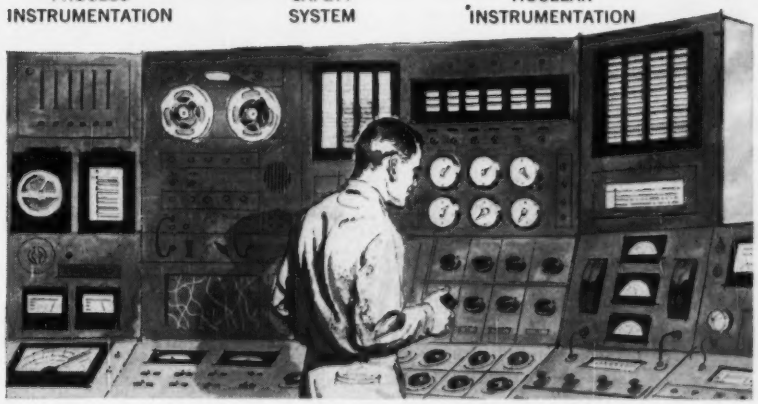


PROCESS INSTRUMENTATION | SAFETY SYSTEM | NUCLEAR INSTRUMENTATION



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New and Improved Products . . .

Automatic Wire Cutter . . .

The *AB-1* automatic wire cutter was designed primarily for the smaller manufacturer who finds it too expensive or impractical to set up a larger machine for short run productions. The device will cut the most commonly used hookup wire and sleeving at the rate of 1,000 feet an hour by simply setting the dial for the length of wire desired from 2½ to 25 inches and then setting the counter to the number of pieces to be cut from 1 to 500. **Electronic Industries, 2624 Perliter St., N. Las Vegas, Nev.**

Push Button Timer . . .

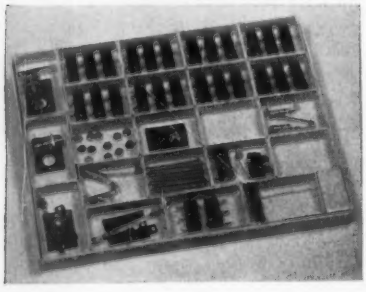
The interval is set in the factory with this new push-button actuated timer. Known as Series *AT-35*, these timers are totally enclosed, motor-driven switching devices for use in vending machines, hand dryers, photo-copying equipment, and similar internal timing control devices. Available for 120- or 240-volt operation intervals, they may be set from 2 seconds to 120 minutes. At the completion of the cycle, the switch opens, de-energizing the load and the timing motor. **Hugh H. Graham and Associates, Inc., New Britain, Conn.**

Vapor-Cooled Transformer . . .

A search for better insulating and cooling mediums led to the use of fluorocarbon compounds where oil-filled transformers would present a serious fire hazard. Nontoxic and explosion-proof, this compound operates effectively at pressures low enough to permit use of conventional transformer tank design. SF_6 gas in the new *URG* load tap changer makes possible completely safe LTC application by eliminating oil in both the transformer and the load tap changer. The voltage range of these substation transformers has been increased from 34.5 kv to 67 kv. **Westinghouse Electric Corp., Pittsburgh, Pa.**

Switch Kit . . .

Thirty-two different types of single-pole, double-throw switches or a variety of combination switches can be devised using the components of this kit. Intended primarily to aid design engineers in development problems, the switches are rated at 15 amperes, ½ hp, 125 and 250 volts a-c. The parts include 8 varieties of actuator assemblies and 12 sets of assembly screws and nuts for stacking combinations of these switches to form multiple units. **American Radiator & Standard Sanitary Corp., Detroit Controls Div., 5900 Trumbull Ave., Detroit 8, Mich.**



Two-in-One Receiver . . .

Here is the latest extension for portable transistor radios. By sliding the radio into a matched companion cabinet with a full sound 5-inch oval speaker, the receiver is transformed from a pocket radio into a cordless table model unit with superior tonal qualities. **CBS Electronics, 405 Park Ave., New York 22, N.Y.**

Traction Drive Elevator . . .

Elimination of the cable equalizing problem for height over 250 feet and simplicity in setting up or dismantling the components are some of the advantages of this new portable personnel elevator. Operating on a monorail principle made up of 10-foot "H" beam sections, the elevator has a capacity of eight men or 2,000 pounds. The traction consists of a pair of driving drums at the bottom of the rail. The second drum is independently adjustable to facilitate cable alignment and equalization. Cable tension is maintained by a system of steel compression springs located in the car. **Hawkeye Products Corp., Iowa City, Iowa.**

Cable Measure Meter . . .

Cables up to 2 inches in diameter may be accommodated with this improved cable meter. Model *HCM* has a direct-drive Veeder-Root counter calibrated in feet and inches and will measure up to 1,000 feet of cable. A swivel wire guide is built in for small wire sizes. An adjustable floor stand is an added feature. **R. J. McFarlin and Co., Cuyahoga Building, Cleveland 15, Ohio.**

Potentiometer Battery Replacement . . .

Operating from any 110-volt 60-cycle outlet, this constant-voltage unit will duplicate in size, output, and terminal positions, a standard 1½-volt square dry cell used in potentiometers as a constant voltage reference source. Both temperature compensated and noncompensated models are available. The assembly contains no tubes or other short-life components and offers the advantage of eliminating errors due to the gradual decrease of dry-cell voltage. **InstruLab, Inc., 1205 Lamar St., Dayton 4, Ohio.**

Electronic Railway Recorder . . .

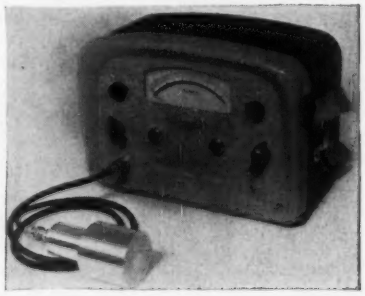
Designed for railway electrification systems, this electronic analyzing recorder will help check and improve the performance of a new high-voltage a-c installation on British railways. A series of recorders that can be synchronized and operated remotely through a master recorder and coded time signals will be installed on electric trains, locomotives, and at points along the test section. Such data as speed and position of trains relative to variations in voltage and electrical consumption under varying load conditions will be recorded on punched tape for subsequent processing by standard computers. **British Transport Commission, 222 Marylebone Rd., London, N.W. 1, England.**

Remote Microphone . . .

The *M-60* combines a 1-channel remote amplifier and a high quality microphone into one compact 12-ounce unit for swift mobility in covering sporting events, spot news casts, and other fast moving, remote broadcasting situations. Entirely self-contained, the mike includes a transistorized amplifier, mercury battery, and an ear-plug headphone. Also provided with the equipment are 18 feet of line and a clip and cord for suspension around the head. **Collins Radio Co., Dallas, Texas.**

Ultrasonic Flaw Detector . . .

Flaws are precisely located in any type of solid material with this portable detecting equipment. Called the *UM* Reflectoscope, the device consists of a time control unit, a pulse-receiver assembly and a 5-inch cathode ray display unit. When the probe is moved across the surface of the material two traces appear on the



screen. One trace presents a straight line which resolves into a pipe the moment a flaw is reached directly under the probe. The size of the pipe determines the depth of the flaw. The other trace shows a square wave to provide the exact distance of the flaw from the end of the piece being examined. **Sperry Products, Inc., Danbury, Conn.**

(Continued on page 20A)

the main characteristic of every Sorgel dry-type transformer is...

QUIET QUALITY

Still setting the industry's pace for lowest sound levels . . . Sorgel's New 1960 Line features additional reductions in size and weight!

A great many independent authorities agree that Sorgel Sound Rated Dry-Type Transformers have historically been the industry's Quiet Quality line. Biggest human reason why: Men with a desire for excellence make Quiet Quality a crusade at Sorgel. Significant results: (1) The industry's lowest sound level. (2) Unexcelled overload capacity. (3) Unequalled operating efficiency. (4) Long range economy. Proof: Certified tests and case history engineering data, furnished upon request, substantiate Sorgel's Quiet Quality performance. Customer benefits: Complete satisfaction and appreciation.

Sorgel also offers these proven advantages:

- **Lower Copper Loss** — *Coils are liberally designed for the most effective use of the latest developments in insulating materials, have large air ducts for low hot spot temperature and are vacuum-impregnated to provide a co-ordinated insulation system.*
- **Lower Core Loss** — *Cores are designed with the industry's lowest magnetic flux densities, resulting in low core loss and the lowest sound level. E. 'ire unit is secured within a substantial frame. Large units are mounted on vibration dampers to minimize vibration transmission to adjacent areas.*
- **Quicker, Easier Installation**—*The enclosure is self-supporting and entrance can be made on sides, top, bottom, or back. Connecting is made easier by means of solderless connectors on terminal blocks in roomy connection compartments. Units up to 75 Kva single phase and 45 Kva 3 phase are furnished for interchangeable wall or floor mounting.*

The same quiet SORGEL transformers are also incorporated in substations. Procurable with any type or make of switchgear, or from any electrical manufacturer. Contact Sorgel today for the Double "Q" in dry-type transformers . . . Quiet Quality.

1500 Kva, 3-phase, 12,000 volt unit substation with automatic fan cooling system to increase capacity 33%, primary fused load break switch, secondary metering with main fused switch and semi-drawout fusible feeder air circuit breakers.

45 Kva 3-phase transformer with taps. Interchangeable wall or floor mounting. Front panel removed, showing interior.

Complete Line for Every Purpose up to 10,000 Kva, up to 15,000 Volts, Including Special Transformers and Saturable Reactors

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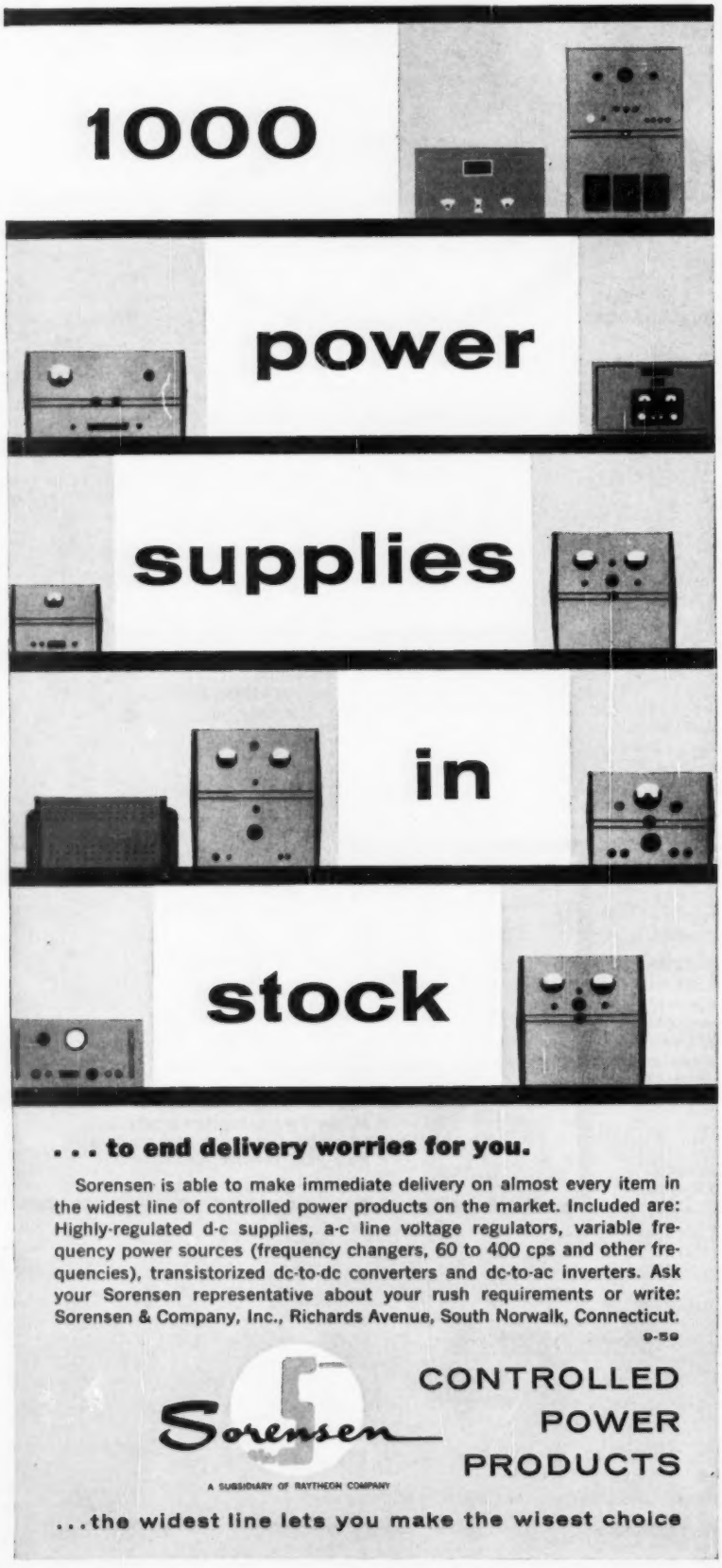
Sales engineers in principal cities. Consult the classified section of your telephone directory or communicate with our factory.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. . . the widest line lets you make the wisest choice

New & Improved Products

(Continued from page 18A)

Test Instrumentation Modules . . .

Comprising five modules of master gauge, tyratron, power supply, difference computer, and sum computer, the components may be combined into a system to inspect and test for hardness such items as ball and roller bearings, pistons and pins, crankshafts, and similar metal-working end products. The *DC 7* Difference Computer subtracts measurements from two master gauges to calculate taper, parallelism, and similar dimensional characteristics. The *SC* Sum Computer is used to calculate over-all dimensions. **Radio Corporation of America, Camden 2, N.J.**

Fotoceram Grid Board . . .

Electronic designers can now make and remake their own high quality printed circuit layouts for prototypes without leaving their laboratories. The board is made of Fotoceram clad on both sides with copper that can be etched away as desired. The grid for installation of components consists of 0.052-inch round holes spaced 1/10 inch apart on center. In using the board, a designer first covers the area he wants to use for circuitry with an etching resistant and then uses hydrochloric acid and ammonium persulfate for removing excess copper. **Corning Glass Works, Bradford, Pa.**

Digital Positioning Control . . .

For use with press feeders, conveyors, pipe mills, and similar industrial applications, this latest control will measure predetermined amounts of material into a press or shear and accurately stop it for the cutting operation. The device uses a pulse to represent an extremely small but exact increment of sheet distance. A battery of five cold cathode counting tubes progressively count the pulses emitted by a pulse generator. Different sheet lengths and production line speeds can be made by setting the proper pulse count selector switch. Rapid slow-down to the cut-off point without intermediate inching is one important advantage the digital system has over the analog. **Reliance Electric and Engineering Co., 24701 Euclid Ave., Cleveland 17, Ohio.**

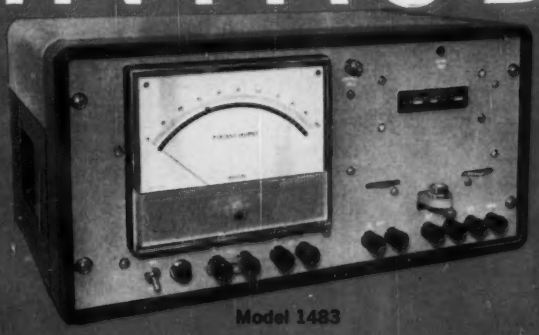
Instrument Motor . . .

A fractional d-c motor designated Type *B* combines small size and low power drain with high torque. Of unorthodox design, the motor has neither revolving windings nor a sliding commutator. Features include a rigid polyethylene case, an Alnico rotor, and a unidirectional start that will not operate if the battery voltage is reversed. Output torque is up to 40 ounce-inches at 1 r.p.m. **Brailsford & Co., Inc., 670 Milton Rd., Rye, N.Y.**

(Continued on page 22A)

a new type
primary standard
for measuring
AC/DC power

INTRODUCING



Model 1483

THE WESTON ELECTRONIC WATTMETER

- Transfer accuracy between DC and AC is within 0.01%
- Unprecedented versatility and reliability

CHECK THESE FEATURES:

- **NEGLIGIBLE STATIC FRICTION** between pivot and jewel bearing to affect accuracy. A small-amplitude vibration is fed constantly to the sensing element—makes possible resolutions down to .01% — 1/5 the resolution of the best indicating meter.
- **NO SPRING FATIGUE** — Springs have been eliminated.
- **TEMPERATURE COMPENSATED** — reduced self-heating errors.
- **LOW EDDY CURRENTS** — due to ferrite shields. Frequency compensated.
- **NO MUTUAL INDUCTANCE ERRORS** — The coils are oriented at 90°.
- **SUSTAINED ACCURACIES DOWN TO 10% POWER-FACTOR.**
- **ONLY ONE POTENTIOMETER** needed for DC Standardization—other wattmeters need two Type K pots, multiplying costs . . . and errors.
- **READ-OUT VERSATILITY** — can actuate remote indicators, digital meters; drive strip-chart recorders, integrators; used in parallel or alone.

With the development of its Model 1483 Electronic Wattmeter, Weston now brings to AC and DC power measurement a degree of accuracy which extends even beyond the traditional accuracy of Weston's indicating type dynamometer wattmeters. With quick, precise operation, the Model 1483 provides a low impedance DC output that can be measured by present day highly accurate techniques. Truly, here's a new concept in quality and capability.

For full information, contact your local Weston representative . . . or write to Daystrom-Weston Sales Division, Newark 12, N. J. *In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ont. Export: Daystrom Int'l., 100 Empire St., Newark 12, N. J.*

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Nelson Class 497 Steel Switchrack with Explosion-Proof Network Protectors, Current Limiters, and Weatherproof Bus Duct installed at a Petroleum Refinery in Class 1, Group D, Division 2, hazardous location.

THE ***dependable name for electrical control equipment in the petroleum industry.***

When control equipment is specified for Class 1, Group D, hazardous locations investigate NELSON . . . first. Be guided by 20 years of engineering and manufacturing experience that assures you of getting the highest quality, easiest installed electrical equipment.

For safe, dependable products, and personalized service, call your NELSON representative.

Among the explosion-proof products designed for Class 1, Group D, hazardous locations manufactured by NELSON are:

- CIRCUIT BREAKERS
- PANELBOARDS
- CONTROL STATIONS
- PIPE LINE SAMPLERS
- SWITCHRACKS
- MOTOR STARTERS
- CONTROL and TRANSFER SWITCHES
- JUNCTION BOXES
- HIGH-VOLTAGE MOTOR STARTERS

a major source of electrical control equipment for industry

NELSON *Electric* MANUFACTURING CO.
TULSA, OKLAHOMA

New & Improved Products

(Continued from page 20A)

Assembly Time Calculator . . .

With this slide-rule-type calculator, one can estimate the average time required to manufacture assemblies in different quantities, determine savings on repeat runs, calculate the efficiency ratings for particular operators or shops, decide the effect of the number of operators on manufacturing time, and evaluate the number of units to be manufactured before reaching "standard" time. The basic data fed into the calculator are the type and number of operations comprising the complete assembly. **Manufacturing Laboratories, 507 Fifth Ave., New York 17, N.Y.**

Proximity Switch . . .

Here is a switch that will operate without physical contact but contains no transistors, tubes, relays, amplifier, and requires no input power. An armature carrying a set of silver contacts disposed within the field of enclosed permanent

magnets provides the motive force. Normally closed contacts are held positively closed by the magnetic field. When a foreign ferrous part is brought into the sensing area of the field, the armature snaps its contact to the opposite position and will hold it until the foreign part is removed. **General Equipment and Manufacturing Co., Inc., 116 S. Campbell, Louisville 6, Ky.**

Miniature Telephone System . . .

Stressing compactness and economy, the Rapidofon push-button intercom was designed for small factories, business firms, stores, and institutions. One advantage over the conventional "voice box" type of intercom is that each phone in the 7-station system can communicate independently with each other. A universal circuit also permits an electrical hook-up between the office front door and each telephone so that visitors may be admitted by pressing a designated button. **Tele-Norm Corp.,** 55 W. 42nd St., New York, N.Y.

(Continued on page 32A)

Component Specification: ARNOLD

TOROIDAL CORES — Aluminum and Plastic Cased

SILECTRON CORES — Types C, E and O

BOBBIN CORES — Stainless Steel and Ceramic

The ARNOLD LINE-UP includes ANY TAPE CORES you need

APPLICATIONS

We'll welcome your inquiries on your Tape Wound Core requirements for Pulse and Power Transformers, 3-Phase Transformers, Magnetic Amplifiers, Current Transformers, Wide-Band Transformers, Non-Linear Retard Coils, Reactors, Coincident Current Matrix Systems, Static Magnetic Memory Elements, Harmonic Generators, etc.

ENGINEERING DATA

For data on the various types of Arnold Tape Cores, write for these Bulletins:

TC-107A—*Silectron Cores, Types C, E and O*

TC-101A—*Toroidal Cores, of Supermalloy, Deltamax and 4-79 Mo-Permalloy*

TC-108A—*Bobbin Cores*

TC-113A—*Supermendur Tape Cores*

ADDRESS DEPT. EL-01

Arnold produces Silectron C, E and O cores, aluminum and plastic cased toroidal cores of high-permeability materials, and bobbin-wound cores to meet whatever your designs may require in tape thickness, material, core size or weight.

As a fully integrated producer, Arnold controls every manufacturing step from the raw material to the finished core . . . and modern testing equipment permits 100% inspection of cores before shipment.

Wide selections of cores are carried in stock as standard items for quick delivery; both for engineering prototypes to reduce the need for special designs, and for production-quantity shipments to meet your immediate requirements.

• *Let us help you solve your tape core problems.* Check Arnold, too, for your needs in Mo-Permalloy or iron powder cores, and for cast or sintered permanent magnets made from Alnico or other materials. Just write or call *The Arnold Engineering Company, Main Offices, Marengo, Illinois.*

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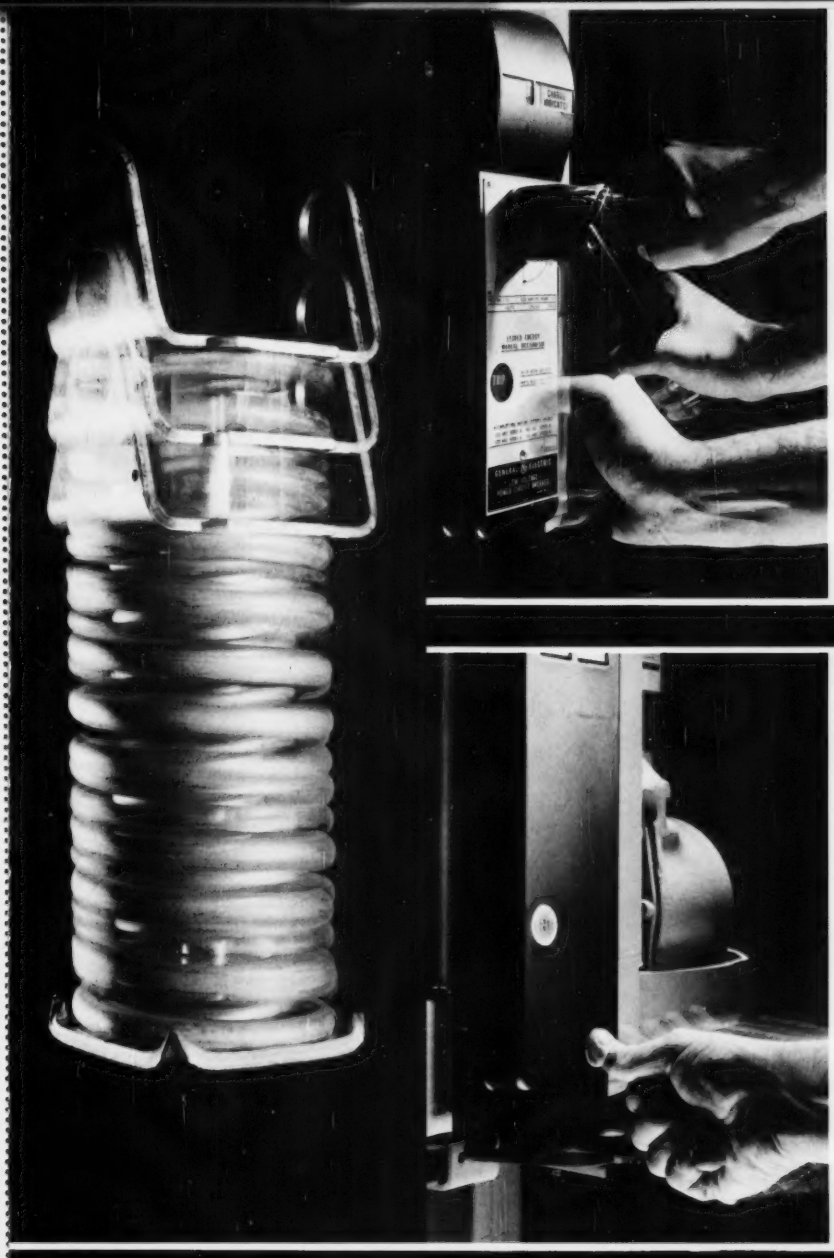

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Industry's ONLY COMPLETE LINE of STORED-ENERGY low-voltage Power Circuit Breakers

SEE COMPLETE G-E LINE

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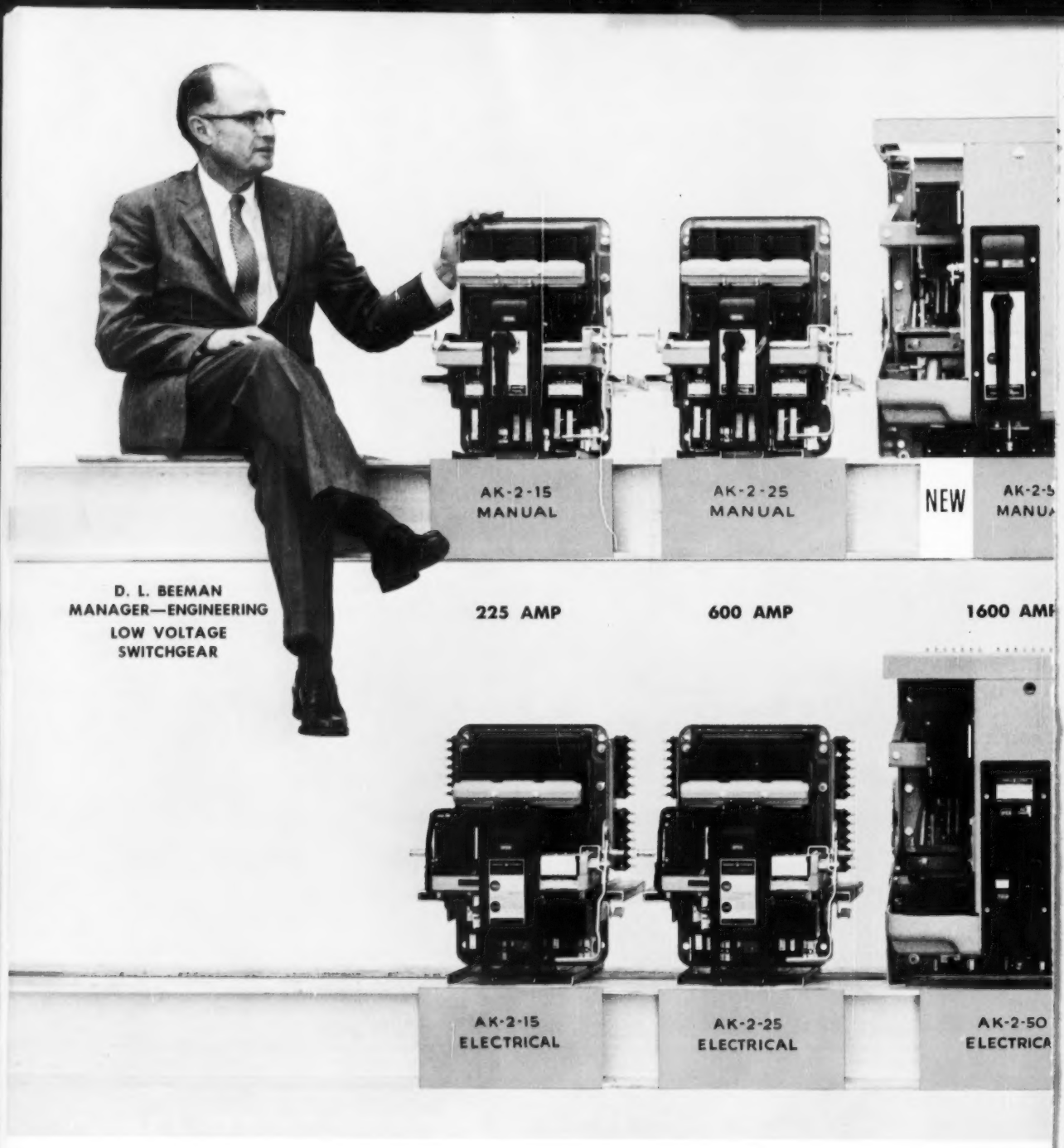
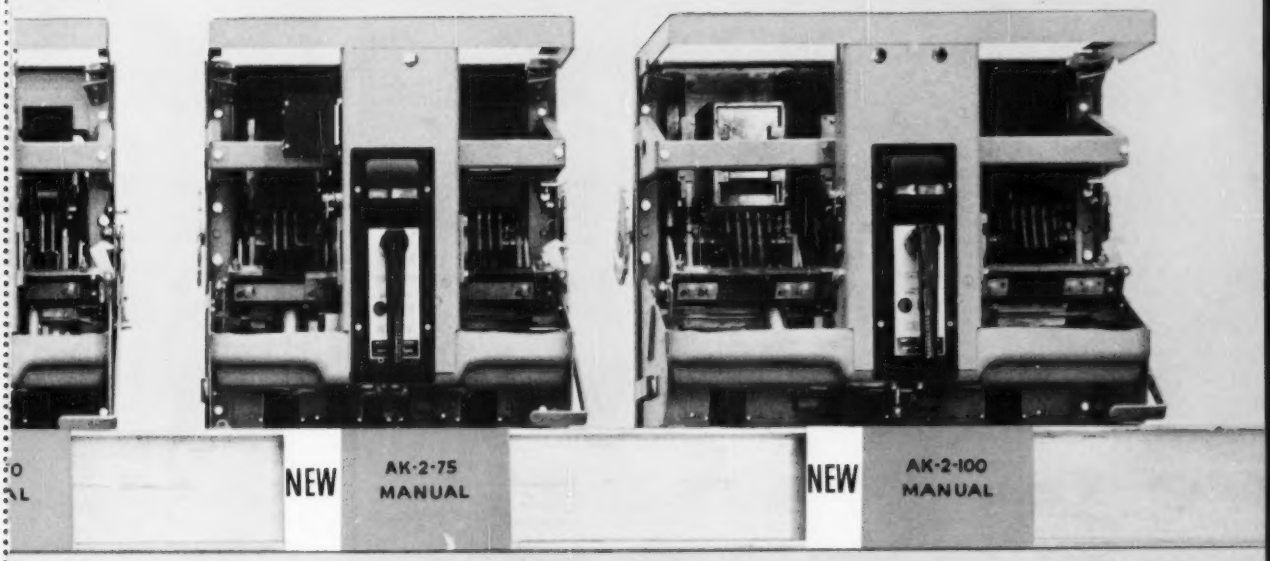
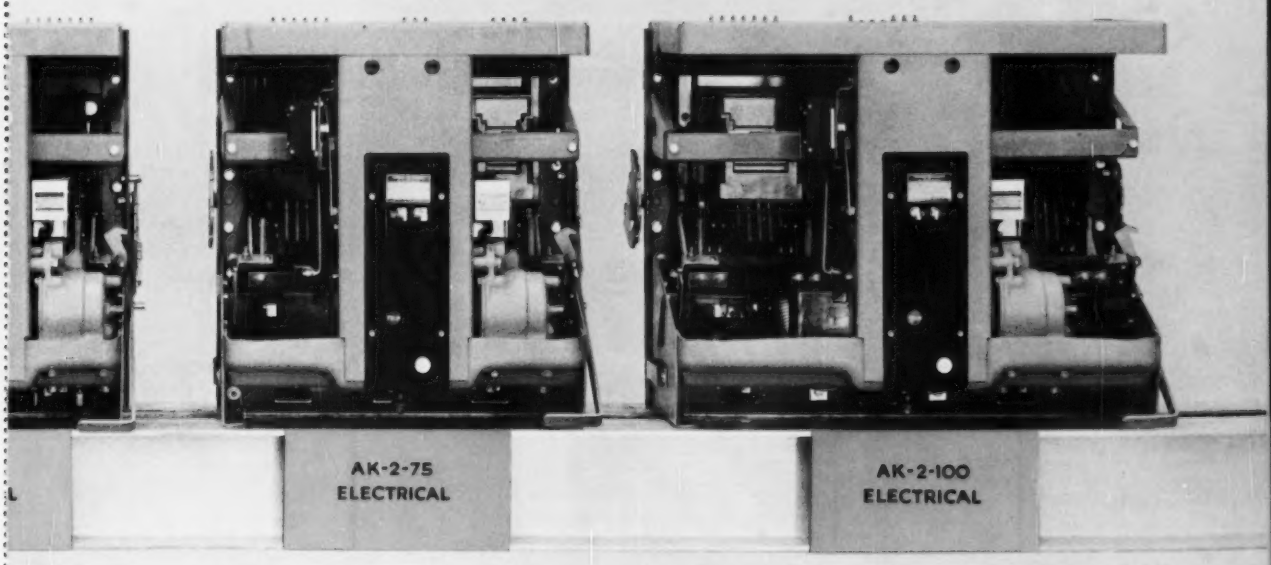


Stored Energy in <u>All</u> These Breakers Means Better Protection at Lower Cost



3000 AMP

4000 AMP



All General Electric power circuit breakers 600 volts and below now employ modern stored-energy (spring-close) mechanisms . . . which can be operated either manually or electrically.

General Electric AK-2 breakers with stored-energy give better service through increased safety, longer life, easier maintenance and application versatility.

TURN THE PAGE TO FIND OUT WHAT THIS FULL LINE CAN DO FOR YOUR SYSTEM.

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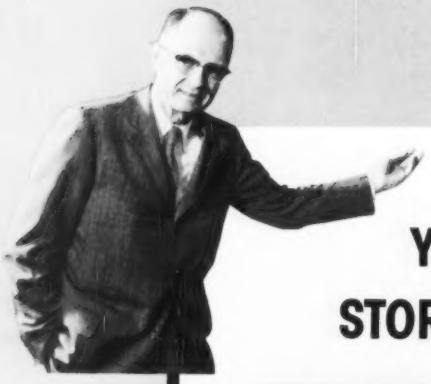

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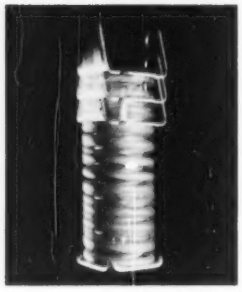

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The stored-energy breaker will last longer, need less attention because it closes with constant force.

You'll Save Money With MANUALLY OPERATED STORED ENERGY

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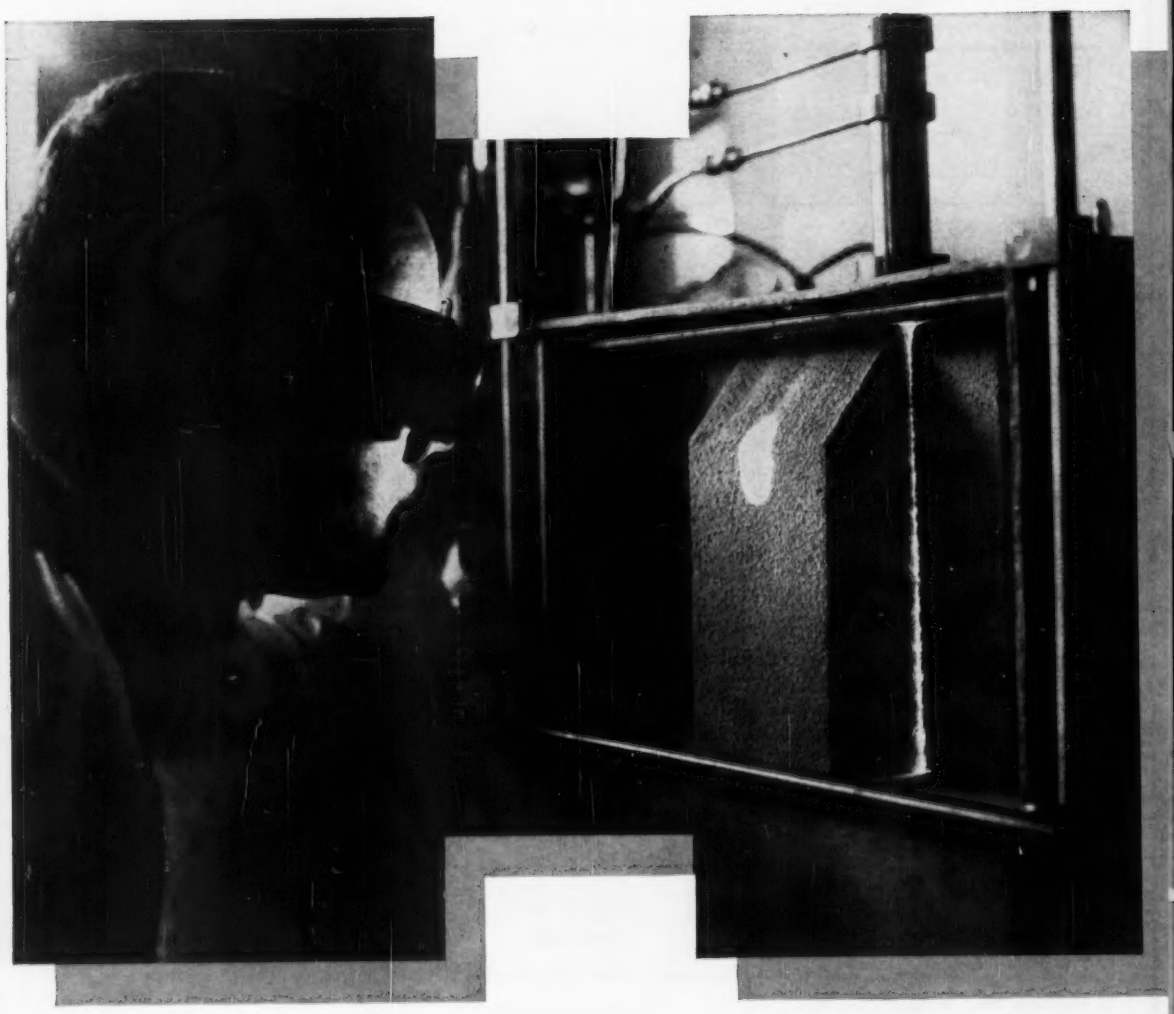

century

Development *of new and highly reliable direct display storage and microwave tubes is being carried on at the Electron Tube Division, Hughes Products.*

In medieval times, alchemists spent lifetimes trying to transform the commonplace into the precious without success. Today, in the Hughes Research Laboratories, scientists and engineers using advanced methods and equipment, are synthesizing many new and precious materials to be used in solid state research.

The photograph, for example, shows a Hughes Research Laboratories scientist observing the growth of an yttrium aluminum garnet crystal using the flame fusion method. This work, as well as other crystal growth techniques, is part of a major Hughes materials research and supply program for the synthesis of ruby, sapphire, spinel, ferrite, garnet and related oxide single crystals. These materials provide atomic circuit elements which are the key to quantum electronics.

As solid state research at the Hughes Research Laboratories continues to expand and intensify, a supply of new and tailor-made materials in the form of high-quality single crystals is essential. Effective utilization and improvement of existing and new crystal growth methods requires extensive knowledge of their range of applicability, crystal growth mechanisms and the relationships between growth parameters and perfection of the resulting materials.

Materials research is contributing significantly to existing ferrimagnetic, paramagnetic and absorption spectroscopic studies...and is opening new areas of investigation by providing materials not previously available as large single crystals.

Other Hughes activities cover practically every part of the electronics spectrum...providing stimulating outlets for creatively-oriented engineers. These include: Space Vehicles, Nuclear Electronics, Ballistic Missiles, Advanced Data Handling and Display Systems, Infrared Devices, Three-Dimensional Radar...and many others.

The variety and advanced nature of Hughes projects provides an ideal environment for the scientist or engineer who wishes to increase his professional stature.

Feedback *in the form of performance data and suggestions for modifications to advanced Hughes Systems is provided by Hughes Field Engineers.*

Newly instituted programs at Hughes have created immediate openings for engineers experienced in the following areas:

Electroluminescence	Field Engineering
Infra-red	Equipment Engineering
Plasma Physics	Commercial Sales
Digital Computers	Microwave & Storage Tubes
Systems Design & Analysis	Communications Systems
Circuit Design & Evaluation	Micro Electronics

Write in confidence to Mr. D. E. Eikner
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BIDDLE *Instrument News*

BIDDLE DIELECTRIC TEST EQUIPMENT

. . . for measuring direct current at voltages up to 100 kv when applied to the insulation of generators, transformers, bushings, cables, etc.

More and more engineers are leaning to d-c testing with voltages equal to or somewhat greater than equivalent peak alternating voltages. Their experience and increased knowledge and appreciation of the advantages of testing with direct voltage have accelerated the need for test equipment to meet field requirements.

IMPORTANT FEATURES

- Well-designed provisions for utmost safety
- Simple operation and reliable performance
- Excellent output voltage regulation
- Compact, mobile design
- Facilities for voltage and leakage current measurements

IMPORTANT APPLICATIONS

. . . *in development* . . . for testing the d-c dielectric strength of insulating materials and the adequacy of the electric design of insulation in any type of electrical equipment.

. . . *in production* . . . for non-destructively detecting defects in the insulation of electrical equipment due to design, material, and workmanship.

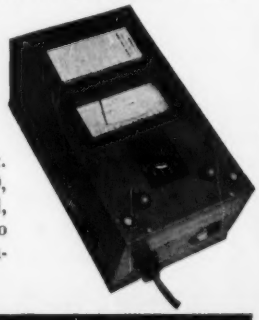
Write for BULLETIN 22-EE.

BIDDLE CORONA TEST EQUIPMENT

. . . for use in non-destructive or breakdown dielectric tests on electrical insulating materials, individual insulation structures and insulation of electrical equipment like cables, transformers, switchgear rotating machinery, capacitors, bushing and communication apparatus . . . for measuring corona starting and extinction voltage, apparent corona charge, relative corona current.

Write for BULLETIN 66-EE.

SIX-VOLTAGE MEGGER®
INSULATION TESTER



Rectifier-operated from any 115 v, 60 cps Circuit. Single Range, 10,000 megohms at 500, 750, 1000, 1500, 2000, 2500 volts d-c. Completely self-contained, one-man operated Megger Instrument designed to meet the growing needs for multi-voltage insulation tests. **Write for BULLETIN 21-20-EE.**

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New & Improved Products

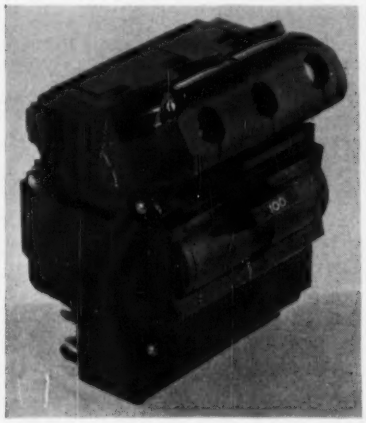
(Continued from page 22A)

A-C Power Speed Control . . .

A line of eddy current coupling adjustable speed drives is now available in ratings from 5 to 100 hp and incorporates significant engineering design advances. Called the Kinatrol speed variator, the apparatus operates from a standard a-c power line. The standard package includes a drive unit, control enclosure, and operator's station. The drive is controlled from the operator's station which includes push buttons and a speed setting dial. **General Electric Co., Schenectady, N.Y.**

3-Pole Circuit Breaker . . .

The latest 3-pole 100-ampere Stab-lok circuit breaker, only 3 inches wide, extends the present line to 240-volt, 3-phase branch circuit use. Features include an improved thermal magnetic trip action, "stab-in" construction, and a unique dual-break contact structure which splits the



arc for instant extinction. The *3P100* is dual-rated, meaning it is approved for use as a plug-in main circuit breaker in a standard 3-phase load center or as a branch circuit breaker in either a load center or NALP panelboard. **Federal Pacific Electric Co., 50 Paris St., Newark 1, N.J.**

Solid-State Television Camera . . .

Weighing only 15½ pounds and hardly larger than a shoe box, this new transistor-powered television camera is actually a complete closed-circuit broadcasting station. Its ability to function from standard house current or a 12-volt battery makes the apparatus readily portable. Any standard television receiver may be connected to the unit. In addition, the camera is said to be so simple to operate that anyone can learn to handle the control after a few minutes instruction. **Philco Corp., 4700 Wissahickon Ave., Philadelphia, Pa.**

(Continued on page 34A)

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It's **KERITE** *that makes the difference*

KERITE CABLE

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Branches in Ardmore, Pa., Birmingham, Boston, Cleveland, Chicago, Houston, St. Louis, Portland, Ore., San Francisco, Glendale, Cal., Seattle

Off the Shelf...

IMMEDIATE DELIVERIES OF GUARDIAN® STEPPERS

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If you have a stepper problem the solution is closer than you think. Your nearest distributor listed here carries quantities of Guardian steppers in stock: continuous rotation; electrical reset; add and subtract; sequence selecting; programming and latching in addition to Guardian relays, switches and solenoids.

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Electronic Industrial Sales, Inc.
2345 Sherman N.W., Wash. 1, D.C.
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Newark Electric Company
223 W. Madison, Chicago 6, Ill.
N.W. Radio & Elect. Supply Co.
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Interstate Supply Co.
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Burstein-Applebee Company
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Contact Electronics
2403 Farrington Dallas 7, Texas
Radio, Inc.
1000 S. Main, Tulsa 19, Okla.

FAR WEST
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Andrews Hardware
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CANADA
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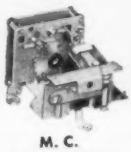
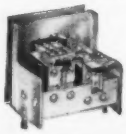
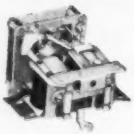
Toronto, Ontario, Canada

P. C.
CONTINUOUS ROTATION


M. C.
CONTINUOUS ROTATION


P. E. R.
ELECTRICAL RESET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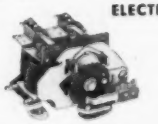
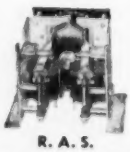

M. A. S.
ADD AND SUBTRACT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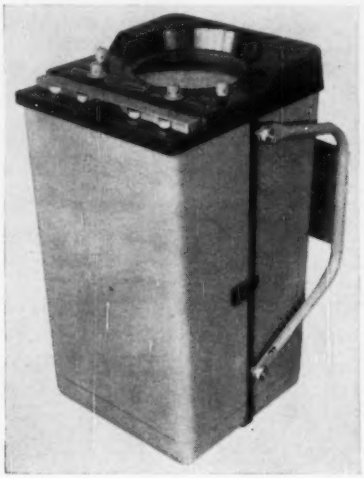
New & Improved Products

(Continued from page 32A)

Low-Cost Radar . . .

For those who own a large boat and feel that radar is a necessary addition to boating equipment such as depth sounders, radio telephone, direction finders, gas detectors, automatic pilots, and the like,



this latest compact no. *1700* radar featuring a 7-inch scope with four range scales of ½, 2, 6, and 12 miles is available at a reasonable price. **Raytheon Co., Waltham 54, Mass.**

Meter Reading Case . . .

Utilities using punched cards for billing customers can simplify this work with a new type of data-processing equipment. The product, a meter reading case, holds 300 or more tabulating cards arranged in the same order the utility employee follows in making his daily round. Data are transferred directly to the card with a sensing pencil instead of the meter book, thus eliminating a recopying operation in the billing office. **The Wright Line, Inc., Worcester, Mass.**

Sound and Vibration Analyzer . . .

This portable, wide-range, narrow-bandwidth, all-pass response analyzer has a 10:1 span on each of four ranges and operates from 2.5 cps to 25 kc. The narrow bandwidth is wide enough to embrace the small frequency fluctuations arising from normal speed variations of engines, machines, and appliances. The alternate 1/3 octave bandwidth is available for the first time at low vibration frequencies. The analyzer is a tunable voltmeter whose bandwidth is a constant percentage of the center frequency consisting of two RC-tuned selective amplifiers which can be either synchronously or stagger-tuned to produce a 1/3 octave bandwidth. **General Radio Co., West Concord, Mass.**

HERMETICALLY YOURS...

What's your choice for terminating sealed compressor header pin circuits? A three-receptacle cluster block? Individual pin receptacles? Individual tab receptacles? Whatever way you design your header circuits, AMP has the solderless terminal you need.

These three A-MP products (above) are quick connect / disconnect types — all have uniform crimp reliability and outstanding vibration resistance. They offer positive wiping action yet will not score header pins—they may be used internally or externally on compressors—and all three fit .090″ pin specifications. Tab receptacles also fit .125″ pins.

For sound, long life performance in the presence of oils and refrigerants—for high speed application to your leads at low cost—specify one or all of these A-MP units for your compressors. Top terminal quality is yours, hermetically sealed.

Send for more information today.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

A-MP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Japan

One of a series

Resolving the driver-car-road complex

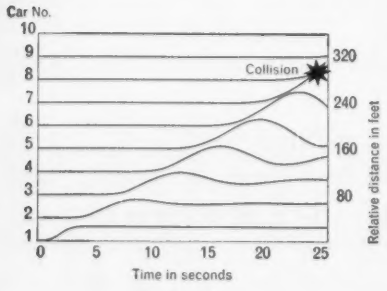
The manner in which vehicles follow each other on a highway is a current subject of theoretical investigation at the General Motors Research Laboratories. These studies in traffic dynamics, coupled with controlled experiments, are leading to new "follow-the-leader" models of vehicle interaction.

For example, conditions have been derived for the stability of a chain of moving vehicles when the velocity of the lead car suddenly changes – a type of perturbation that has caused multiple collisions on modern superhighways. Theoretical analysis shows that the motion of a chain of cars *can be stable* when a driver accelerates in proportion to the relative velocity between his car and the car ahead. The motion is always unstable when the acceleration is proportional only to the relative distance between cars. Experimentally, GM Research scientists found that a driver does react mainly to relative velocity rather than to relative distance, with a sensitivity of reaction that increases with decreasing distance.

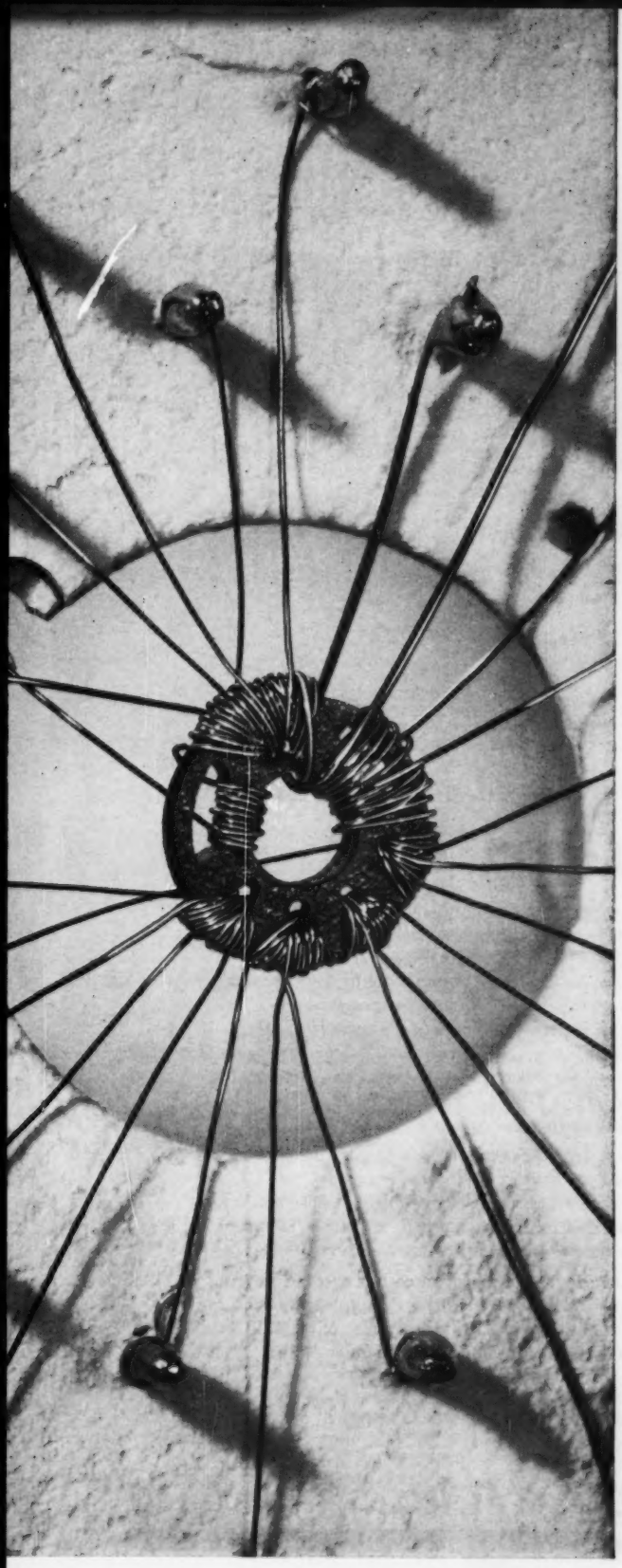
Traffic dynamics research such as this is adding to our understanding of intricate traffic problems – what causes them, how they can best be resolved. The study is an example of the ways GM Research works to make transportation of the future more efficient and safe.

General Motors Research Laboratories

Warren, Michigan



Relative positions of 10 hypothetical cars after lead car goes through maneuver. Amplitude of instability increases, resulting in a collision between 7th and 8th cars.



opportunities in
systems development

Capturing Logic in a Magnetic Web

This web was "spun" by IBM scientists and engineers.

It's a ferromagnetic, multiapertured core. It permits more versatile circuits, new techniques, new data storage concepts—all never before possible with basic toroidal cores.

For, instead of just two flux patterns provided by toroidal cores—now multiple patterns are possible. And instead of basic read-out being destructive, thus limiting logic facility, with the new multiaperatured core, read-out is nondestructive; binary information read from one output does not affect the information state of other outputs.

Perfection of this small, lightweight, magnetic device was not an easy job. It took the skills and cooperation of top-flight physicists, electrical and mechanical engineers, and mathematicians. It also took the progressive spirit of an organization wishing to maintain leadership in its field.

If magnetics is not your primary interest, you might be more interested in IBM achievements in optics, or cryogenics, or microwaves. Or you might be interested in the advances IBM people are making in semiconductors, inertial guidance, and human factors engineering. In all these fields, you'll find IBM offers a world of opportunity to the individual who wants to do "the impossible."

Right now, there are several key openings in IBM's expanding research and development staff. If you have a degree in engineering, mathematics, or one of the sciences—plus considerable experience in your field, why not write, describing your qualifications, to: Mr. P. E. Strohm, Dept. 550M, IBM Corporation, 590 Madison Avenue, New York 22, N. Y.

You are invited to visit IBM while in New York City for the American Physical Society meeting.

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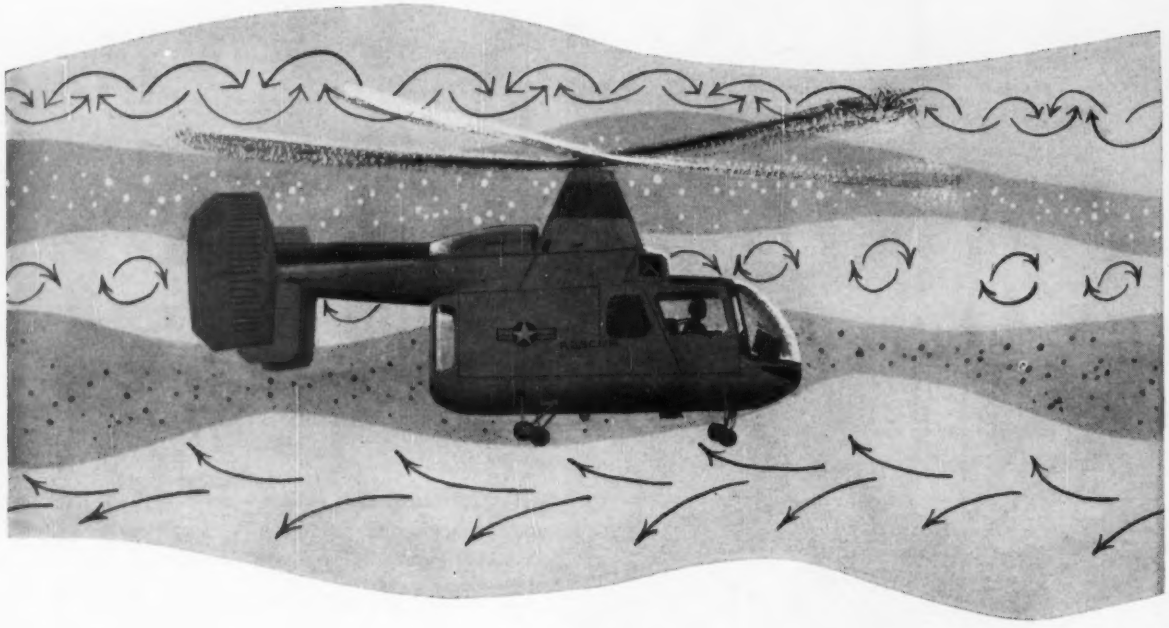

sta-bil'i-ty

Poised in recovery or skimming straight and level — in any attitude — stability augmentation from American-Standard steadies the Kaman H-43B Huskie. This USAF rescue helicopter adds one more high performance vehicle to the growing list of applications for our subminiature inertial components. In aircraft — the F-106, in missiles — the Terrier and Tartar, and in submarines — the Polaris class, American-Standard, Military Products Division supplies gyros fundamental to accurate positioning and control.*

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Winning this degree of acceptance has created new career opportunities in advanced design, production and applications engineering. American-Standard, Military Products Division, Norwood, Massachusetts.

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NEW OPPORTUNITIES FOR ELECTRICAL ENGINEERS IN ADVANCED REACTOR DEVELOPMENT

Expanding programs at The Knolls Atomic Power Laboratory have created a number of new positions in electrical engineering for which specific nuclear experience is not necessarily a prerequisite. Right now, some intriguing exploratory work is going on involving new reactor concepts. You are invited to inquire about immediate openings in:

CONTROLS & INSTRUMENTATION ANALYSIS

To provide by analysis and/or evaluation of tests the quantitative predictions of present powerplant systems for future applications. Should have BSEE or ME.

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To design, develop and construct special electronic instrumentation. Qualifications should include BSEE, major in electronics, with 5-10 years experience in pulse techniques, digital computer circuitry, servo-amps, low current linear and logarithmic amps, transistors.

POWERPLANT EQUIPMENT

To determine systems requirements, design systems, prepare vendor equipment specs, evaluate vendor's proposals and follow vendor's designs in assigned areas such as rod control, reactor protection, main coolant control, steam plant control or feedwater control. Initiate proposals for development and test programs. Should have BSEE or BSME with 2-5 years experience in industrial or electronic control, powerplant mechanical equipment and instrumentation.

ALSO OPENINGS IN:

Electrical Facilities Design
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Electrical Distribution Systems

U.S. CITIZENSHIP REQUIRED

Please forward your resume in confidence, including salary requirement, to Mr. A. J. Scipione, Dept. 27-MA

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sta-bil'i-ty

A note for talented engineers:

Stability at American-Standard is the result of dynamic action and can mean a lot in terms of professional growth at the expanding Military Products Division.*

The logical growth from the projects already in the house extends a tremendous challenge. And, the "off-site" advantages are as stimulating as the in-plant creative environment.

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• There are many more features in Acme Electric class H insulated transformers in addition to the basic advantages of lighter weight and smaller size per KVA. Quietness is achieved by better core and coil design and contruction. Noise level of this line of standard transformers never exceeds the decibel ratings established by NEMA standards.

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There are other features too, that are important! Core and coil construction provides air ducts through which the natural flow of air can dissipate heat. Thus external case remains at safe 40°C level.

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Class H transformers are now available in single phase ratings from 1 to 25 KVA for wall mounting, 37½ KVA and larger for floor or platform mounting. Three phase ratings from 3 to 15 KVA for wall mounting, 30 KVA and larger for floor or platform mounting. All standard voltages available.

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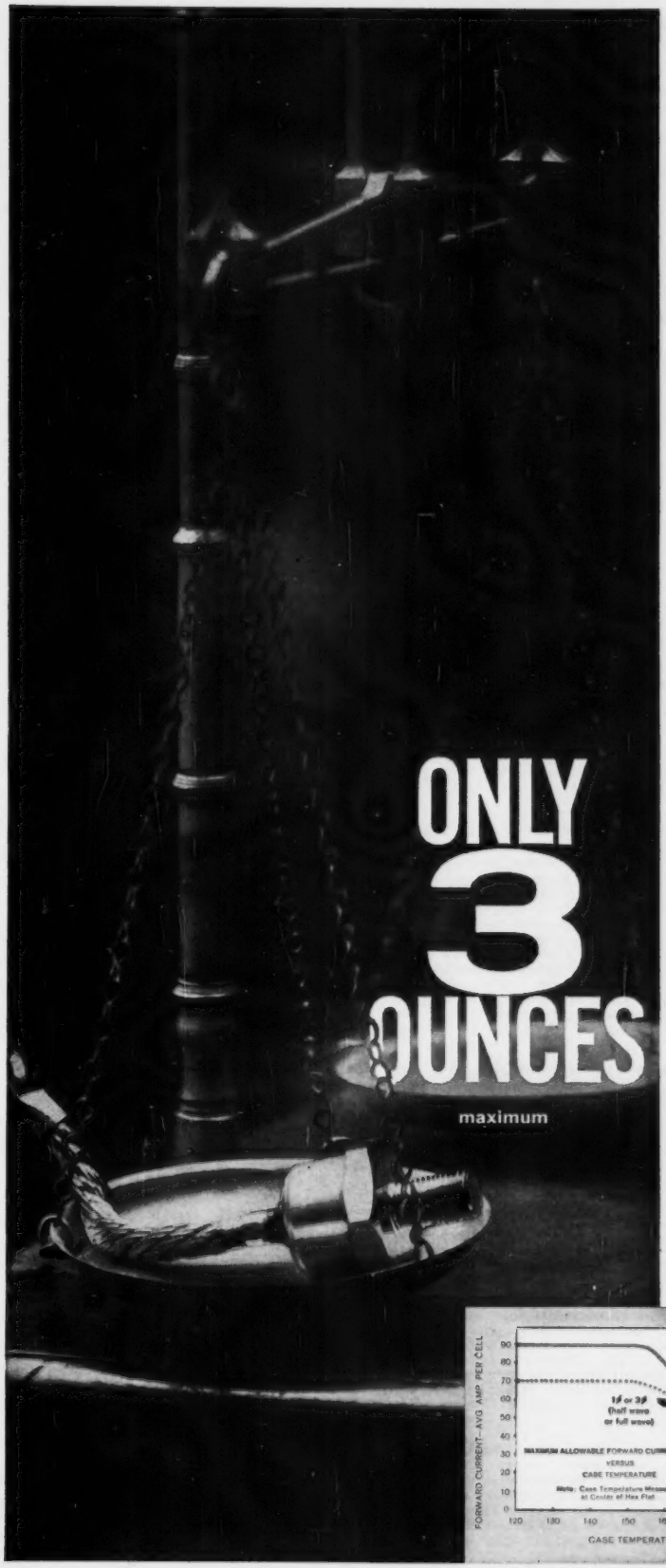
Send your resume to Box 59, Electrical Engineering, 33 West 39th Street, New York, N. Y.



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This latest Westinghouse rectifier has been designed specifically for those high-current applications where space and weight are critical. Total weight is only 3 oz., maximum.

OUTSTANDING FEATURES INCLUDE...

- Low leakage current
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- Lightweight
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- High current for its size and weight

ELECTRICAL CHARACTERISTICS

Maximum allowable peak inverse voltage: Operating or transient to 50 to 500 volts.

Maximum allowable dc blocking voltage: 80% of PIV.

Maximum reverse current: 30 milliamperes peak at rated peak inverse voltage.

Maximum one cycle half-wave peak rating: 1200 amps.

Operating temperature: Up to junction temperature of 190° C.

Cell forward current: See curves.

Operating frequency: For frequencies beyond 1 kc, refer to Westinghouse.

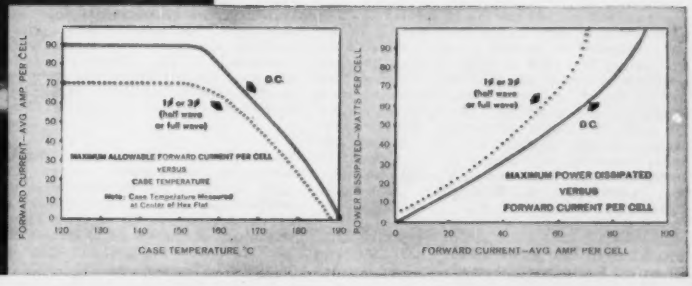
Thermal drop: Junction to case, 0.4°C/watt.

Inquiries and sample orders are invited. For complete technical data contact your local Westinghouse representative.

YOU CAN BE SURE...IF IT'S

Westinghouse

Westinghouse Electric Corp., Semiconductor Department, Youngwood, Pa.


FORWARD CURRENT—AVG AMP PER CELL
D.C.
1ϕ or 3ϕ (half wave or full wave)
MAXIMUM ALLOWABLE FORWARD CURRENT PER CELL VERSUS CASE TEMPERATURE
Note: Case Temperature Measured at Center of Hex Flat
CASE TEMPERATURE °C
POWER DISSIPATED—WATTS PER CELL
MAXIMUM POWER DISSIPATED VERSUS FORWARD CURRENT PER CELL
FORWARD CURRENT—AVG. AMP PER CELL

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STAFF IN ELECTRICAL ENGINEERING. Attractive positions combining teaching (graduate and undergraduate) and research are available. Appointment at any level from assistant professor up, depending on qualifications. A person with interests in electrical energy conversion and modern electrical machines is especially sought, but openings in other fields are available. Applicants must have Ph.D. or equivalent evidence of research potential. Write, Chairman, Division of Engineering, Brown University, Providence 12, Rhode Island.

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ELECTRICAL ENGINEER. Experienced in substation maintenance rotary and rectifier type, or signal and communications work. Send confidential reply giving personal resume and required salary to C. Edward Thorney, Superintendent of Personnel, Chicago North Shore and Milwaukee Railway, 650 Waukegan Avenue, Highwood, Illinois.

ELECTRICAL ENGINEER. Wanted by midwest manufacturer of products sold to electric utilities. Previous sales experience desired. Related engineering, editorial, advertising or sales promotional activities will be considered. Strong company offers excellent working conditions, opportunity for advancement and good salary. Send complete resume to Box 63.

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INTERESTING POSITION WITH OPPORTUNITY for young Electrical Engineer in Minneapolis headquarters service department of manufacturer of larger industrial motors and controls. Excellent future for right man. Box 50.

ELECTRICAL ENGINEERS. Several challenging foreign assignments as design or construction supervisory engineers by graduate Electrical Engineers with minimum of seven years of experience in the operation and construction of overhead and underground electric utility systems. Experience should include work with transmission lines, distribution lines, or substations, or protective relaying normally associated with large utility systems. Work assignment is for minimum of 18 months in far-eastern nation where consulting engineering services will be required for several years, to expand a 100,000 kw utility system to ten times its present size. Scope of work requires many engineers of varying experience. Married men with small families are preferred. Salaries commensurate with experience, but generally $12,000 to $17,000 annually with furnished homes provided. Travel and household goods shipment costs paid. Send resumes to MINER AND MINER, CONSULTING ENGINEERS, INC., 5598 South Broadway, Littleton, Colorado.

SENIOR LEVEL POSITION for experimental research in plasma physics. Broad research opportunity for a creative and competent experimentalist. Send resume to AeroChem Research Laboratories, Inc., P. O. Box 12, Princeton, New Jersey

UNIVERSITY APPOINTMENTS ELECTRICAL ENGINEERING. Three openings including the Chair in Electrical Engineering in New Faculty of Applied Science with opportunity for advancement and research. Attractive salary schedule. New building under construction. Ph.D. or Master's degree desirable. Apply to: F. A. DeMarco, Principal, Essex College, Windsor, Ontario.

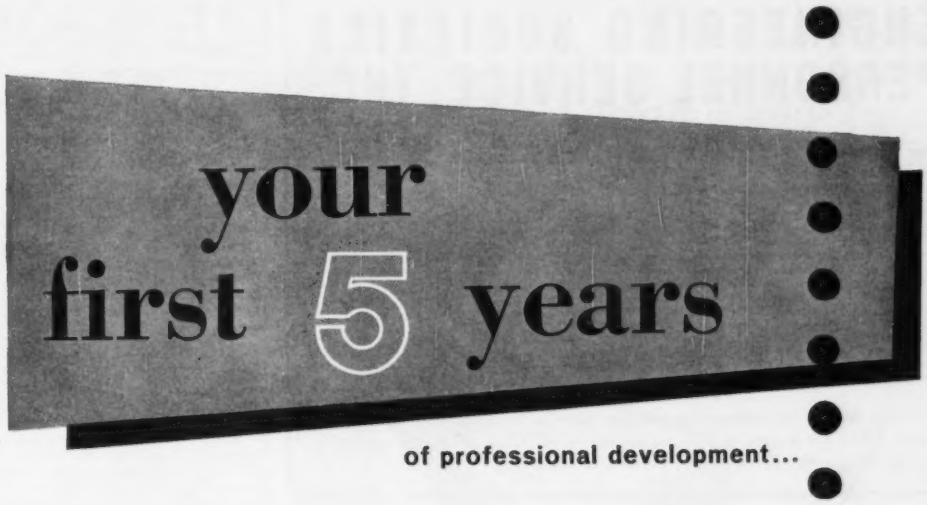
ELECTRIC MOTOR DESIGN ENGINEERS—fractional horsepower motors from 25 cycles through 1600 cycles—single, two and three phase. Salary offered will be commensurate with experience. Submit resume of experience, education and salary requirements. Degree not required. Skurka-Langdon Engineering Co., 4002 N. Mission Road, Los Angeles 32, California.

Positions Wanted

PROTECTION ENGINEER 42, presently responsible for relay system in medium size utility. Familiar with system operation, substations and power plants. Desires relocation and challenging projects. Box 60.

ENGINEER, E.E., P.E.—15 years electrical and industrial experience in operation, maintenance and construction of chemical, food processing, etc., plants. 9 years experience in design, specification, field supervision, liaison of industrial (chemical and pharmaceutical), institutional and commercial projects. Home New York. Box 64.

A.I.E.E. TRANSACTIONS wanted to buy for cash back volumes and sets, also other scientific and technical Journals—E. E. ASHLEY, 27 East 21st Street, New York 10, New York.



A new KIT for young engineers now available through ECPD contains the following popular publications:

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   A 48-page reference manual for young graduate engineers consisting of selected papers by William Wickenden, including the "Second Mile."

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   A statement of ethical principles in professional life, relations with the public, with clients and employers, and with other engineers.

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ENGINEERING SOCIETIES PERSONNEL SERVICE, INC.

(Agency)

New York	Chicago	San Francisco
8 West 40th St.	29 East Madison St.	57 Post St.

These items are listings of the Engineering Societies Personnel Service, Inc. This Service, which cooperates with the national societies of Civil, Electrical, Mechanical, Mining, Metallurgical, Petroleum, and Chemical Engineers, is available to all engineers, members and non-members, and is operated on a nonprofit basis. If you are interested in any of these listings, and are not registered, you may apply by letter or resume and mail to the office nearest your place of residence, with the understanding that should you secure a position as a result of these listings you will pay the regular employment fee of 5% of the first year's salary if a non-member, or 4% if a member. Also, that you will agree to sign our placement fee agreement which will be mailed to you immediately, by our office, after receiving your application. In sending applications be sure to list the key and job number.

When making application for a position include eight cents in stamps for forwarding application to the employer and for returning when possible.

A weekly bulletin of engineering positions open is available at a subscription rate of $3.50 per quarter or $12 per annum for members, $4.50 per quarter or $14 per annum for non-members, payable in advance.

A NEW SERVICE TO EMPLOYERS AND EMPLOYEES

The Engineering Societies Personnel Service, Inc. has just announced that effective December 1, 1959 a new bulletin of "Engineers Available" will be published and distributed bi-weekly to several thousand employers in the eastern states. This bulletin will be distributed free of charge and will contain a short synopsis of the experience of engineers who have registered with the Service and are seeking a new position. This new publication is part of an expanded program designed to increase the effectiveness of the service to both employer and employee.

Any employer interested in receiving this bulletin should so advise E.S.P.S. at 8 West 40th Street, New York, N. Y. and your name will be placed on our mailing list. Any engineer who is registered with the Service or wishes to register is entitled to a 35-word notice in the bulletin. Write to the New York office for forms. Your qualifications will be brought to the attention of employers on our mailing list without revealing your identity.

It is planned that this publication will be extended very shortly to include the midwestern office, located at 29 East Madison Street, Chicago, Ill. and the western office at 57 Post Street, San Francisco, California.

The present employment market for engineers is very active and there are positions available in management, operations, design, research and development as well as in sales, etc. Therefore, those engineers who are really seeking now positions are encouraged to register with the Service at this time giving us the opportunity of processing your registration and making direct referrals to positions for which we believe you would be qualified and interested in. Utilize the services offered by E.S.P.S. to your advantage.

Men Available

MANAGING ENGINEER, B.S.C.E. and B.S.E.E., 47. Central Station utility and industrial including power distribution and transmission; control, relaying and instrumentation. Registered Pennsylvania, New York and Florida. Seven years' substation and line design and construction; six years' switchgear application and design; 14 years' consulting, power plant and industrial. Five years' supervisory experience. Any location. E-160.

ELECTRICAL ENGINEER, graduate, 49. Over 24 years' experience in design of transformers. Audio interstage, driver, modulation and output transformers. Also power transformers, single and three phase; saturable reactors, pulse and voltage regulators. Location desired; New England or Florida. E-161.

SUPERVISING ENGINEER, B.S.E.E., 40. Design and application, electrical equipment—seven years', large electrical manufacturer, several patents-ten years', supervisory experience central staff in a large chemical company plus three years' line supervision engineering and maintenance group. Location desired; anywhere in U.S. E-1016-Chicago.

ELECTRICAL ENGINEER, B.S.E.E., 38, four years' with electrical utility in relay department, short circuit studies, relay and fuse coordination. Three and a half years' with consultant, designed electrical power and control systems. Location desired; Southeast. E-1021-Chicago.

ELECTRICAL DESIGNER: EE, 41. Twelve years design, supervision of construction of power plants, military bases, substations, distribution systems, refineries, pumping stations for construction and oil companies. One year operation and maintenance of diesel ships. $10,000. Prefer: Foreign, California, South. Home: San Francisco. Se-1303.

FACILITIES ENGINEER: EE, 31. Broad seven years experience electric power field including industrial high and low voltage distribution system design and operation, motor controls, working with contractors and maintenance foremen. Prefer: U.S. or Foreign. Home: Washington. Se-988.

SENIOR ELECTRICAL DESIGNER: EE (Austria), 57. Well experienced on electric power systems, studies, reports, design, steam and industrial power; also manufacture, design and development of pumps. Registered Electrical Engineer in California. $9000. Prefer: San Francisco East Bay or Los Angeles Area. Se-1432.

DESIGNER OR MAINTENANCE ENGINEER: 51. Experienced in design of heavy machinery, dredges, piping and valves, power plants, materials handling equipment. Technical supervision over selection, installation and maintenance of many types of mechanical and electrical equipment. $8400. Prefer: San Francisco Bay Area. Home: California. Se-500.

INDUSTRIAL ENGINEER: EE (Switzerland), 57. Thirteen years experience on plant layouts, material handling, machinery and equipment requirements, production cost estimating, market research, systems and procedures, incentive plans on warehousing, factories, paper conversion, aluminum producing; sales of electric switchgear and apparatus; plant engineer for installation of new sisal factory; test, quality control of electrical apparatus; test of electric and steam equipment. $7200. Prefer: West Coast or Any Location. Home: San Francisco. Se-358.

MARKET RESEARCH OR PROGRAMMING: 29. Five years operation research studies for marketing and product planning, military electronics, instrumentation and analyses of research project. Two years operation officer in Navy (Completed). $9500. Prefer: San Francisco. Home: New York. Se-277.

SYSTEM OR SWITCHGEAR ENGINEER: 30. Good academic training with six years electrical apprenticeship (varied manufacturing experience) followed by three years experience high power testing of all types of switchgear and five years manufacturing and utility fields on substation and hydro-plant design. $7800. Prefer: San Francisco Bay Area. Home: Canada. Se-813.

DESIGNER, DEVELOPMENT: EE, 50. California Electrical Engineer License. Twenty years experience in charge of engineering, supervising product design, development, cost, field service on manufacture of electric products, pneumatic equipment, stationary and mobile, air convevors, air blast equipment, abrasive recovery machinery, svclines and separators for manufacturers; also design, installation, maintenance, training in naval science and warfare and communications systems. $10,000. Prefer: San Francisco Bay Area. Home: San Francisco. Se-445.

Positions Available

NEW YORK OFFICE

DIRECTOR OF ADVANCED TECHNOLOGIES MARKETING, B.S. and M.S. in physical science, and/or engineering; Ph.D. and some study in management and in marketing would be desirable. Experiecne should include a minimum of two years' research laboratory or technical production; a minimum of three years' industrial selling; minimum of five years' industrial marketing management; and a minimum of two years' government procurement. Will represent the research laboratories in the investigations of new product proposals which are outside the scope of the product divisions; develop company policies for marketing of all divisions to the U.S. government; establish and maintain an R & D marketing program for the company with government; coordinate marketing to the U.S. government across all divisions. Medium-sized, multi-division company, in electronics. Location, East. W8050.

ELECTRONIC DESIGN ENGINEER in Microwave components, degree in electrical engineering or physics, with a minimum of two years' in the design of duplexers, isolators, directional couplers, antennae and similar devices. Good design and evaluation ability is a must. Will do individual and close work on research and development on radar and navigational devices, instruments and solid state devices. Salary open; good fringe benefits. Location, New England. W8063.

ELECTRICAL ENGINEER, graduate electrical, with a minimum of five years' experience to supervise three or four electrical engineers preparing quotations and electrical contracts for steel mill equipment. Salary, $10,800 a year. Location, western Pennsylvania. W8068.

ELECTRO-CHEMIST, graduate electro or physical chemist with research experience and/or graduate degrees; good academic background and knowledge of the following: Thermodynamics and kinetics, and colloid, physical, organic, inorganic and electro-chemistry. Will conduct basic and development research into the oxidation of aluminum in baths, electro-chemical processes; dyes; and the anodizing, plating, and bonderizing of metals. Salary, $7920-$9000 a year. Placement fee and relocation costs paid. Location, Virginia. W8070.

ELECTRICAL DESIGNER, 30-40, for the design of high voltage facilities, relays, preparation of wiring diagrams. Salary, $8060-$8580 a year. Location, New York, N.Y. W8080.

(Continued on page 46A)

UP TO
37 CHANNELS
IN THE
Voice Band
(300 to 3000 CPS)

with Comvor®
DATA TRANSMISSION TERMINAL

RFL Model 912
Operates over Wire Circuit or Microwave

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Reliable HIGH-SPEED Continuous Control
of
PUMPS
VALVES
MOTORS
GENERATORS
RELAYS
ETC.

The Model 912 Comvor, an audio frequency shift terminal, is used in the transmission of telemeter, telegraph or control signals over either wire line, microwave, or carrier. Up to 90 individual information channels are available in the audio spectrum.

Reliable frequency shift method of keying is used. All essential controls such as transmitter output level and receiver input level are included.

Each terminal contains its own power supply which provides an additional 60 milliamperes at both the transmitter and receiver for the operation of relays, stepping switches, selector magnets, and other components used in telemetering, control and telegraph applications.

WE CAN HELP YOU
Our Applications Department is ready to assist you in your control, telemetering or communications problem. Phone DEerfield 4-3100.

Write for Technical and Application Data.

Radio Frequency
LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

"LOOK...THE TOP OF THE POLE IS FOR THE BIRDS! DON'T TAKE ANOTHER STEP TIL YOU SEE HOW WE'RE REGULATIN' THIS BUSINESS OF POLE CLIMBING!"

LOOK FOR BIG NEWS COMING FROM THE ORIGINATORS OF 5/8% STEP REGULATORS
A-1193
ALLIS-CHALMERS

Industrial Notes...

Radio Frequency Co.
Medfield, Mass. . .

A recent installation of an RFC high frequency induction heater, by Radio Frequency Company, Medfield, Mass. for Commercial Controls Corp., a subsidiary of Friden, Inc., has taken over the job of soft soldering type slugs to type bars on typewriter type bar and segment assemblies, and has improved quality and increased production. A pull test which measures the force necessary to separate the soldered pieces also showed an increase, using the same solder and flux originally used with gas. A 100% increase in production was achieved when the type bar and segment assemblies were checked on the comparator. The force of the gas flame had evidently been instrumental in forcing the slugs out of position while soldering, necessitating more time for aligning the type on the comparator.

Webber Gage Co.
Cleveland, Ohio . . .

A new method for inspecting and recording gauge block accuracies, developed for Webber Gage Co., 12900 Triskett Rd., Cleveland, Ohio, incorporates specially designed electronic equipment and is said to eliminate human error in the calibration of gauge blocks. It is also said to speed up Webber's inspection service so that blocks sent in for inspection can be returned to owners in a very short time. The equipment consists of a high-precision electronic comparator which measures gauge blocks to an accuracy of one-millionth of the new international inch, and a digital voltmeter, which shows gauge block size visually, and automatically sends impulses to an electric typewriter. The typewriter then automatically records correct sizes on the Webber certificate.

(Continued on page 47A)

Personnel Service, Inc.

(Continued from page 44A)

PRODUCTION TEST ENGINEER, graduate electrical, with three to eight years' production test experience. Must be capable of systems and component testing; write inspection and test procedures. Test equipment design, construction and maintenance, supervise test engineers and technicians. Capable of directing and trouble shooting electrical problems on production lines. Salary, $8500-$11,000 a year. Location, New York Metropolitan area. W8089.

SALES ENGINEER OR ASSISTANT TO SALES MANAGER, for inside sales work, graduate electrical with experience in microwave components, to coordinate work with customers and sales representatives; handle correspondence; prepare advertising on new products, etc. Salary $8000-$15,000 a year depending upon experience. Location, Connecticut. W8095.

ENGINEERS. (a) Electrical Project Engineer, Product Development, small electro-mechanical devices, including miniature relays; graduate, with three to five years' experience in development of related products such as relays, controls, instruments, solenoids, regulators, switchgear, etc. Will handle or direct on a three-man team basis all development phases of new products. (b) Product Design Engineer on small electro-mechanical devices including miniature relays; graduate mechanical or equivalent with a minimum of five years' experience in design of related products such as relays, controls, instruments, solenoids, regulators, switchgear, etc. Will apply knowledge of manufacturing processes to produce practical production designs of new products. Salaries open, benefits include profit sharing, etc. Company pays placement fees; relocation assistance given. Location, North Jersey shore. W8100.

ELECTRICAL ENGINEERS, graduates, with three to five years' experience in development and design in electro-mechanics, components, controls and circuitry. Include in application salary requirements. Location, central New Jersey. W8110.

ELECTRICAL MOTORS ENGINEERS, young, graduate electrical, with experience in design and/or application of electric motors, to review design of large electric motors for pumps drive. Some pump experience desirable. One to three years' experience required. Salary, to $8400 a year. Location, western Pennsylvania. W8111.

POWER PRODUCTION ENGINEER for an electrical utility, 30-37, graduate mechanical or electrical preferred, with some supervisory ability as well as power plant experience. Location, Southwest. W8165.

BUYER, ELECTRICAL EQUIPMENT, engineering degree preferred, to 35, with several years' of responsible purchasing experience, in non-defense industry, to purchase all electrical motors and controls for two plants of a heavy equipment manufacturer. Should be familiar with modern purchasing methods and controls. Salary, to start, about $8500 a year. Location, Midwest. W8167.

SALES ENGINEER, Electronic, graduate electrical preferred, to contact the aircraft, missile and other related industries, selling several lines of highly technical electronic and electro-mechanical components. Heavy experience in this field required. Salary and incentive, $10,000-$15,000 a year range. Territory, Georgia, Alabama and Florida. Prefer resident of Florida as it will be operating base. W8168.

APPLIED RESEARCH ENGINEER, graduate electronic, electrical or mechanical, with development experience in non-destructive testing or instrumentation related to ultrasonic, transducers, physical testing and laboratory measurements. Instrumentation background should be one of pulse and video circuits and display systems. Three to five years' industrial experience or equivalent univeristy research experience. Salary, $7500-$10,000 a year. Limited travel. Location, Connecticut. W8172.

APPLICATION ENGINEER, mechanical or electrical graduate, with five to seven years' experience, to apply standard ultrasonic instruments to unusual test problems that require automatic alarm and rejection features, requiring background in ultrasonic nondestructive testing. Work will include the design of automatic inspection equipment for sheet stock, bar stock and general regular shapes; also irregular shaped pieces as found in castings and forgings. Salary, $6500-$9200 a year. Limited travel. Location, Connecticut. W8173.

TEACHING PERSONNEL. (a) Instructor in electrical engineering, Master's degree. (b) Instructor in mechanical engineering, Master's degree. (c) Associate Professor of electrical engineering, for courses in electronics, Master's degree. Salaries commensurate with training and experience; 8½ school month. Location, Pennsylvania. W8178.

DEVELOPMENT ENGINEER, B.S.E.E., electronics major; must have experience in design, testing and/or manufacturing phases of VHF omni-range monitor equipment or precision phase generating for measuring equipment. Government work; production company. Salary open. Company will pay placement fee. Location, southern New Jersey. W8182.

DESIGN ENGINEERS, B.S.E.E., with five years' minimum experience in power supply design magnetic amplifier regulating system design, for the design of packaged power supply units for ground, shipboard, aircraft and missile applications, to work reliably under wide temperature extremes and under severe environmental conditions. Salary, $8000-$10,000 a year depending upon experience, background. Location, Pennsylvania. W8184.

ELECTRICAL ENGINEER for a product development department, graduate electrical, with one to three years' experience. Duties will include design, testing and coordination of new product development, direct draftsmen and technicians in carrying out work on projects. Should be capable of developing new products for electro-mechanical products. Salary open, depending upon education and experience. Location, upstate New York. W8186.

ENGINEERS. (a) Tax Depreciation Engineer in public utility, 30-35, with experience in utility properties combined with statistical experence. Company wll train in tax work. Salary, $9000-$10,000 a year. (b) Junior Engineer to work as understudy to above. Location, New York, N.Y. W8188.

ENGINEERS. (a) Senior Project Engineer, electrical graduate, with design, estimating, and production experience on military electronic equipment. Salary, $10,000-$14,000 a year. (b) Electronic Engineer, electrical graduate, with at least five years' circuit design experience in radar and computer fields including experimental and prototype equipment. Salary, $8000-$10,000 a year. Location, lower Connecticut. W8191.

SENIOR TECHNICAL WRITER, degree in electronic, electrical engineering or equivalent, with a minimum of three to four years' experience as a technical writer for a company or technical publication firm publishing handbooks to government specifications. Knowledge of production techniques. Will do technical writing in the electronic, electrical and electro-mechanical field. Salary, to $10,000 a year. Location, lower Connecticut. W8192.

SALES MANAGER, Electronic, graduate electronic or electrical engineer, with at least ten years' experience in sales engineering, including five years' sales manager with corporation activity in research, development and manufacturing of electronic instruments, systems and subsystems. Position is with fast growing electronic engineering and manufacturing organization. Submit resume, salary requirements. Location, New York suburban area. W8212.

Wear Your ◆ AIEE Badge

ELECTRICAL ENGINEER, graduate, for company which develops, designs and manufactures high quality precision electro-mechanical devices, with two to five years' experience, to design electro-mechanical products such as function potentiometers, rotary switches, etc. Must have interest and aptitude for mathematics and circuitry. Salary, to $9000 a year. Location, New York, N. Y. W8217(a).

SALES MANAGER, 35-42, graduate electrical, with sales management experience in electronics fields, i.e., loud speakers, transformers, soils, etc. Sales are principally OEM to radio, TV, automobile companies and government. Sales force, ten men coast to coast. Salary, $14,000-$17,000 a year. Location, Midwest. W8220.

DATA PROCESSING ENGINEER, 25-35, academic background in electronics, with M.S. in E.E. desired; for fundamental research and study within the area of equipment design concerning data processing technology. Communications or circuit design experience preferred. Salary commensurate with experience. Location, central New Jersey. W8228.

PRODUCT MANAGER for a manufacturer of electric call, signal and alarm systems, 35-45, with a thorough knowledge based upon experience of the national market for sound and coordinated signal distribution system. Familiarity with design and production problems and costs. Will investigate and appraise market potential; collaborate with sales and research and development on design of systems and introduction into field, etc. Salary, $12,000-$15,000 a year with fringe benefits. Location, East. W8233.

PUBLIC UTILITY ENGINEER, to conduct studies, investigations and analyses relating to regulation of the operations, services and rates of utility companies. Three to five years' experience in engineering involving public utility construction, operation and maintenance. Salary, $7860-$10,536 a year. Location, Hawaii. F8241.

ELECTRICAL ENGINEERS. (a) Supervisory Electrical Engineer, B.S. and M.S. in E.E., with Ph.D. in E.E. or Physics highly desirable. At least 15 years' experience in successful electrical engineering design on circuit analysis amplifier theory, servomechanism control theory, pulse and digital circuits, general electronics and electronic and electro-mechanical construction techniques. Salary, to $18,000 a year. (b) Supervisory Electrical Engineer, B.S., M.S. in electrical engineering, with 10 to 15 years' practical design experience of electronic and electro-mechanical devices. Will be responsible for a variety of product and systems designs involving measuring devices and control devices, in electronics, electro-mechanical, mechanical nuclear (measurement-detection) fields. Salary, to $16,500 a year. Location, Ohio. W8243.

ENGINEERS. (a) Assistant Production Manager, graduate electrical, with three or more years' as a production supervisor in the manufacture of electronic industrial control bonus. (b) Supervisor of assembly, test and calibration (electronic equipment), graduate electrical, with three to five years' production technicians in assembling, testing and calibrating electronic equipment; 25-35. Salary, $6000-$7200 a year, plus bonus. Location, Ohio. W8244.

DESIGN ENGINEER, graduate mechanical, with equipment design experience, to work with plant mechanical department handling short term equipment design and small facilities project engineering jobs. Salary open. Location, Pennsylvania. W8246.

APPLICATION ENGINEER, graduate electrical, with from one to three years' experience in electro-mechanical work, preferably on regulators, controls, etc. Salary, $7000-$8000 a year. Location, Connecticut. W8250.

(Continued on page 50A)

Industrial Notes

(Continued from page 45A)

Alcoa
Pittsburgh, Pa. . .

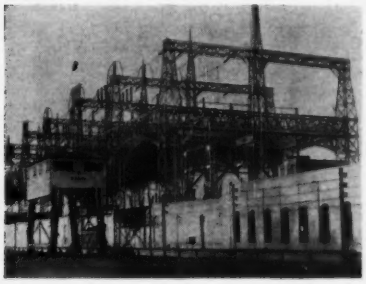
Pocket-sized record players and powerful radios no bigger than a pen or wristwatch today are but a few years away from the market because of the versatility of alumina, a powdery white oxide from which metallic aluminum is made. The prediction is made by the Aluminum Company of America, 1501 Alcoa Bldg., Pittsburgh 19, Pa., which notes that it now is supplying alumina to several ceramic manufacturers for use in tiny blocks, called Micromodules, designed to contain all the elements of a complete electronic circuit.

Marshall Industries, Inc.
San Marino, Calif. . .

The purchase of the entire assets, lease holdings, and inventory of the Electron Products Co., a division of Preco, Inc., by Marshall Industries, Inc., 2065 Huntington Dr., San Marino, Calif., has been announced. Electron Products Co. manufactures precision miniaturized capacitors and radio interference and noise filters. Marshall Industries is a recently established company formed through the merger of three companies bearing the generic name of G. S. Marshall Co., manufacturers' representatives, the Wahlgren Electric Manufacturing Co., and Electro Physics Laboratories, Inc.

Vita-Var Corp.
Newark, N.J. . .

A. O. Allen, vice-president, Vita-Var Corp., 10 Commerce Court, Newark 2, N. J. announces that their research laboratory has developed a multipigment stainless steel paint, no. *13448*, which represents a significant advance in the durability of maintenance paints for exposed steel and aged galvanized iron. According to Mr. Allen, Vita-Var Corp.



co-operated with a large power company in the pioneering of its development. This paint, which contains mixtures of stainless steel flakes and nonmetallic pigments in a long oil alkyd vehicle, has successfully passed 8 years of extensive laboratory and field tests in corrosive areas.

(Continued on page 49A)

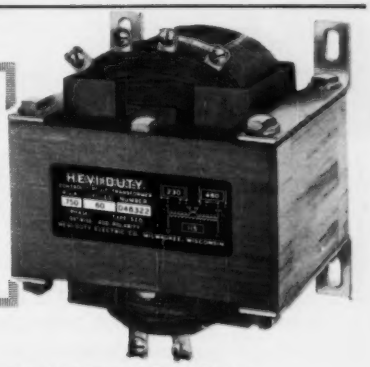
"I'M BUSHED! THIS NEW ROOST IS TOO SLICK TO LAND ON. USED TO BE THESE THINGS WERE FULL OF BUTTONS AND BOLTS--- NOW THEY'RE SMOOTH AS AN ICE-COATED INSULATOR!"

LOOK FOR BIG NEWS COMING FROM THE ORIGINATORS OF 5/8% STEP REGULATORS

ALLIS-CHALMERS

A-1194

you'll have
SPACE to SPARE
on your panel



. . . when you mount the newly designed Hevi-Duty Type SZO Control Circuit Transformer. Savings in panel space range up to 20 percent over units of equivalent rating. Better yet, you'll have extra inrush capacity (up to 150% more) due to Hevi-Duty's interleaved windings and other new improved proportions of design. New Type SZO transformers range from .050 to 5 KVA.

HEVI-DUTY

Write for Bulletin 300 for further details

A DIVISION OF BPC BASIC PRODUCTS CORPORATION

HEVI-DUTY ELECTRIC COMPANY, MILWAUKEE 1, WISCONSIN

Industrial Furnaces and Ovens, Electric and Fuel • Laboratory Furnaces • Dry Type Transformers • Constant Current Regulators

IBM 1620 *data processing system*

...the most powerful engineering computer in its low price class

The new IBM 1620 is a desk-size engineering computer that offers you more computing ability per dollar than any system in its price class.

Transistorized throughout, the IBM 1620 has a 20,000-digit magnetic core memory with variable field length and immediate accessibility. Its input output notation, on paper tape and console typewriter, is in convenient decimal arithmetic. It can perform more than 100,000 calculations a minute and is easily adapted to your engineering problems.

Easy to learn, easy to operate, easy to communicate with, the low-cost 1620 helps free your engineering talent for more creative work. And in keeping with our concept of Balanced Data Processing, the IBM 1620 is supported by extensive services. This includes a comprehensive library of mathematical routines and specific industry programs to permit you to put the 1620 to work without unnecessary delay.

Ask your IBM representative about the unique advantages of the IBM 1620. Like all IBM equipment, it may be purchased or leased.

balanced data processing **IBM**®

Industrial Notes

(Continued from page 47A)

Bell Telephone Laboratories
New York, N.Y. . .

The discovery of a method for pressing rods of commercially available powdered boron has led in turn to successful floating zone melting of that extremely high-melting element. The technique will provide larger crystals for basic research studies of this semiconductor than have been available before. A paper describing the new method was presented by Dr. E. S. Greiner of Bell Telephone Laboratories, 463 West St., New York 14, N. Y., to the Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers. Because of its physical properties, boron does not lend itself to floating zone melting, since it is not possible to form the powder into a suitable shape by pressure alone. The pressed forms are so friable that they crumble as soon as any attempt is made to remove them from the forming dies.

Kulite-Bytrex Corp.
Newton, Mass. . .

Kulite Semiconductor Products, Inc., Ridgefield, N.J., and Bytrex Corp., Newton, Mass., announce the formation of Kulite-Bytrex Corp., a jointly owned subsidiary. The new company was organized to manufacture semiconductor strain gauges and semiconductor strain gauge devices under license from Bell Telephone Laboratories. The company, located at 50 Hunt St., Newton 58, Mass., expects to make a limited number of gauge types.

Du Mont
Clifton, N.J. . .

The two-way mobile radio business of Avia Products Co., Los Angeles, Calif., has been purchased by Allen B. Du Mont Laboratories, Inc., Clifton, N. J. Avia Products has concentrated its mobile radio design and production on rugged, compact, and weather-proof transmitter/receiver units for police motorcycle use, as well as for commercial motorcycles, plant vehicles, bulldozers, and other equipment where the radio must be subjected to extremes of shock and vibration.

Burndy Corp.
Norwalk, Conn. . .

Burndy Electra S. A., European subsidiary of Burndy Corp., Norwalk, Conn., will manufacture electric connectors for users in the Common Market nations in a new plant scheduled for completion in the spring of 1960 in Malines, Belgium. The plant will house a complete machine shop with tool and die facilities, press and assembly operations, and a warehouse. It will serve offices across western Europe.

(Continued on page 51A)

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UPTON, LONG ISLAND, N. Y.

BROOKHAVEN NATIONAL LABORATORY
A Center for Nuclear Research and Development
UPTON-NEW YORK

Personnel Service, Inc.

(Continued from page 46A)

CHICAGO OFFICE

ENGINEERS. (a) Sales Engineer Trainee, B.S.E.E., 22 or more, would require headquarters training if no experience, knowledge of AC rotating machinery and control. Duties: Selling large AC synchronous and induction motors, AC generators, motor control and switchgear. Salary, $5700 and up. (b) Application Engineer, B.S.E.E., 22 or more, preferably some experience, know AC rotating machinery and control. Duties: Handling technical correspondence with field sales offices, preparing bids, checking specifications and recommending proper application of equipment to customers requirements. Can lead to outside sales position. Salary, $5700 and up. (c) Machine Design Engineer, B.S.E.E., 22-45, two or more years' design experience, knowledge of AC rotating machinery. Duties: Designing AC synchronous or induction motors ranging in HP from 100 to 5000 HP, for a manufacturer of induction motors. Salary, $6000 and up. Employer will negotiate the fee. Location, Minnesota. C7808.

ENGINEERS. (a) Sales Engineers, digital computer and or electro-mechanical equipment sales experience required. Salary, $9600, plus, a year. (b) Sales Technical Specialist, M.S. or B.S. in Math and computer application experience. Salary, $7800-$10,200 a year. (c) Mathematicians/Programmers, with two to six years' of computer systems programming applications experience. (d) Electronic Engineers, B.S.E.E. or Physics and computer input-output design and development experience. Salary, $7800-$10,200 a year. Positions open in Chicago, Cleveland and Los Angeles. Employer will pay placement fee. C7775.

PROJECT ENGINEER, (Electrical engineering and Design), graduate E.E. Must be capable of designing electrical equipment combining electronic controls, motors and servomechanisms for use in automatic fusion welding equipment. Will work in Sales Engineering Department as coordinator between developing, engineering, drafting, production, purchasing and sales, with purchasing on critical materials, shortages, inventory levels. Liaison with sales for quotations and requirements of orders received. Company will negotiate placement fee. Salary, $7200-$8400 a year. Location, Chicago. C7774.

ELECTRICAL DESIGNER, E.E. degree desired but not essential, to 40; four years' experience in electrical design and drafting of power plants and industrial installations (power, lighting and control). Duties: Design layout (preparation of drawings if necessary) of power plants, industrial installations, pumping plants, etc., selection of type and sizes of equipment, cables, breakers, etc., estimating costs. Asstiant to Electrical Engineer in preparation of specifications for a consulting engineer. Salary, to $8400 a year. Location, Louisiana. C7773A.

TEST ENGINEERS, Graduate E.E., power option, with one to five years' experience in electrical lab. Sound knowledge of electric circuits. Duties: Electrical test work on power distribution equipment; lab. work and power or impulse testing for a manufacturer of high voltage electrical apparatus. Employer will pay placement fee. Salary, $6000-$8400 depending on experience. Location, Southwest suburb of Chicago. C7772.

SENIOR DEVELOPMENT ENGINEER, E.E. or M.E., to 50. Duties: Creative and analytical ability to design and build sample controls with new functions or lower costs which can be basis of new appliance contro's. Experience in low cost mass production devices. Employer will pay placement fee. Salary, $9600-$15,000 a year. Location, Illinois. C7768.

SAN FRANCISCO OFFICE

RELAYS ENGINEER: EE, young. Preferably with some experience or qualified in testing operating relays and systems to assist on metering and telemetering, analyzing circuit prints study and operate supervisory controls, handle data, logging and load control on substation and transmission line problems. For utility. $6600-$7200. Location: Washington. SJ-4859.

OPERATING ENGINEER: EE or ME, 30-37. With supervisory ability as well as power plant experience on systems about 200 MW with send-out of one billion KWH. For utility. $8000-$10,000. Location: Southwest. Sj-4855.

(a) DESIGN, DEVELOPMENT: EE, age open. Several years experience in advanced electronics instrument development (vacuum tube and transistor circuitry) for analog and digital. Package experience desirable. Salary open. (b) TECHNICIANS: Electronics background, age open. Under one year's experience in electronics (breadboarding, construction and evaluation of electronics circuitry, simple sheetmetal work). Theoretical background in electronics desirable. Salary open. For a manufacturer. Southern California. Sj-4850.

DESIGNER: EE, age open. Minimum two or more years experience in circuitry design of transistorized television monitors, camera control units and cameras; must have formal transistorizing training as well as television circuitry experience. Salary open. For manufacturer. Southern California. Sj4849a.

DESIGNER: EE, age open. Three to five years experience designing transformer, rectifier units, regulated power supplies and mechanical control and transistorized for military applications. For a manufacturer. Salary open. Location: Southern California. Sj-4849b.

SALES, APPLICATION ENGINEER: EE, 25-40. Minimum two years experience selling, preferably electric power apparatus. Will contact and sell circuit breaker type equipment to contractors, consultants and distributors in developed territory for regional office. $7200-$9000, plus mileage and annual bonus. Car required. Location: Northern California. Sj-4837.

DESIGNER: EE, well experienced design, diagramming, computors specifications and plans for industrial and commercial installations (power, light, distribution centers, industrial, interlocking controls), involving feeders, main switchboards, electric machinery, as used in oil and chemical plants, breweries, etc. Strong on short circuit computations. $7800-$9000. San Francisco. Sj-4828.

ELECTRONICS DESIGNER: EE with Electronic major, young. Minimum two years experience after graduation and ability to design electronic circuitry, component specifications and carry production through production engineering; should have knowledge of transistor design and circuitry analysis for manufacturer of computer type equipment. About $7800. San Francisco East Bay. Sj-4813a.

WRITER (ELECTRONICS): EE, with Electronic major, age open. Experienced in design and with demonstrated capability of technical writing for manuals of specifications and other technical descriptions. $7800. For manufacturer. San Francisco East Bay. Sj-4813b.

QUALITY CONTROL COMPUTER: Must have experience in tape recording or allied fields; work and operate department, knowledge of governmental standards; able to handle statistical quality control and develop organizational manual. Establish system to control procurement of raw materials, fabricate parts and components, systematize identification and receiving of material. Provide surveillance of invoice drawings, inspect manufacturing assembly production and packing to assure optimum results. For manufacturer. Substantial salary. San Francisco Peninsula. Sj-4809.

PRODUCT DESIGNER: EE or ME, young. Minimum five years experience tape recording or allied field; assume complete design and responsibility for miniature recorders. For manufacturer. $9000 up. San Francisco Peninsula. Sj-4807.

DESIGNER: EE, young. At least three years circuitry and component design; able to assume complete responsibility for design of transistorized analog and digital circuitry for manufacturer. $7800, up. San Francisco Peninsula. Sj-4806.

SALES ENGINEER: Minimum two years experience electronic components and fundamental knowledge of electronic circuitry or minimum two years experience missile components and system. Salary open. U.S. Citizen; clearance required. San Francisco East Bay. Sj-4810-Rb.

DESIGNER, DEVELOPMENT: EE, advanced degree desired. At least five years engineering experience with specialization in digital and logic circuit design or servo mechanism techniques, to work in development of high speed printers. Experience in digital computers, high speed input and output equipment, data converters, servo systems and application. Knowledge of solid state devices (transistors). $10,800-$12,000. Southern California. Sj-4799-R.

PRODUCTION FOREMAN: Electrical background, age open. Considerable experience in coil winding business. Familiar with coil winding machinery (layer, bobbin, toroidal). Familiar with general machine shop equipment (lathes, drill press, etc.) and vacuum potting techniques. New mechanical component manufacturing company. Excellent opportunity for growth. $7800. San Diego. Sj-4788.

FIELD OFFICE ENGINEER: Prefer EE License. Able to check, inspect, maintain, install fire alarm system for national firm. Should be competent mechanic and assist manager by heading up whole process. Work in industrial plants and public buildings. Some travel. $6000 up. Headquarters San Francisco. Sj-4786.

DESIGN AND PACKAGE ENGINEER: EE, young. Several years experience in instruments development and package experience desired. Must have theoretical and practical development knowledge and be able to design advanced measuring equipment (analog and digital) using both vacuum tube and transistor circuit. For manufacturer. Salary open. Southern California. Sj-4784.

DESIGNER: EE, young. Minimum four years experience in high frequency equipment. Design circuit on mobile communication equipment, VHF and UHF. Up to 1000 m.c., develop new circuit and modify existing equipment. For manufacturer. Salary commensurate. Southern California. Sj-4783.

FIELD ENGINEER: CE or EE, major in structural design, under 30. Experienced in design and construction of structural steel with consultant steel fabricator or contractor. Capabiliy for sales promotion and personal contact work. Demonstrative ability in speaking informally before audience. Must be trained engineer, qualified to understand problems of design and structural steel, who is interested in promotional work and can present his subject well. Salary commensurate. Headquarters Los Angeles. Sj-4782.

FACILITIES ENGINEER: EE, to 35. Two to five years general electrical experience related to engineering department work in any industrial application, for buildings, plants, remote installations, terminals, waterfront or large industrial developments. Work with mechanical, civil, contractors, architects and engineers. For major oil company. $6600-$9600. Southern California. Sj-4872-R.

SALES ENGINEER: Age open, experienced selling to industrial contractors and o.e.m. users of industrial architectural equipment (motors, starters, switchboards and other standard supplies. For electric constructor and motor repair shop. Salary plus commission and expenses. Car required. San Francisco Bay Area. Sj-4779-R.

SENIOR INDUSTRIAL ENGINEER: EE or ME, experienced in industrial work. Experienced in human engineering, work measurements, method studies; to develop new improved system, new concepts and design equipment for postal service. Work closely with postal employees, coordinate (not time study). $8400-$12,000; for manufacturer. San Francisco Peninsula. Sj-4773-R.

DESIGN, DEVELOPMENT: EE, with Electronics major. Well qualified to deal with design, development circuitry and production of marketable electronic equipment. For controls, receivers, transmitters, close circuits and other application. For manufacturer. About $8400. San Francisco. Sj-4771.

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Industrial Notes

(Continued from page 49A)

Motorola Inc.
Chicago, Ill. . .

The U. S. Weather Bureau is installing a 10-mile microwave system to transmit data between computer stations at the National Bureau of Standards (NBS) in Washington, D. C., and the Weather Bureau's National Meteorological Center in suburban Suitland, Md., provided by Motorola Inc., 4501 W. Augusta Blvd., Chicago 51, Ill., the system will take information from a magnetic tape at one station and record it on a similar tape at the receiving station. The tape can then be used as input for the IBM *704* computers used at both stations. The transmitted information will consist of official weather reports assembled at Suitland. These reports will be processed by the NBS computers and the results will be transmitted back to the Suitland station. Computers at both locations are used because of a heavy work load and the need for standby facilities.

American Meter Co.
Fullerton, Calif.

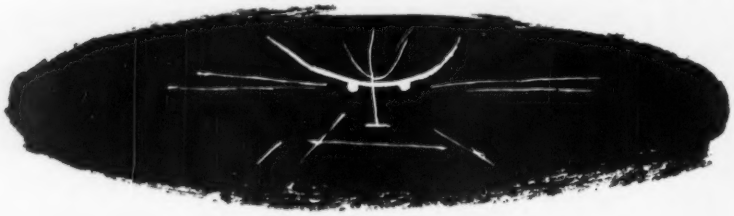
A 65,000-square-foot addition to the American Meter Co. plant has been opened in Fullerton, Calif. This addition, which more than doubles the plant's size, will house all production, customer service, warehousing, and research operations of the company's Reliance Regulator Division. This division, formerly located in Alhambra, Calif., manufactures gas pressure regulators for commercial, industrial, and domestic applications.

Industrial Patent Research Co.
Columbus, Ohio . . .

A unique service especially tailored for management and research development staffs of electronics, petroleum processing, petrochemical, chemical, pharmaceutical, and related firms is being offered by Industrial Patent Research Co. (IPR). The service entails the reduction of technical patents to easily understood digests of basic principles. These short summaries of patents, free from legal terminology and redundant detail, can be scanned and understood in a few minutes by scientific personnel. Clients of this service can assimilate 50 to 100 or more patents a week in less time than is required to review a single lengthy patent, when provided with these concise patent analyses. Patents to be analyzed are provided by the client to IPR which then prepares the analyses in accordance with an agreement established between the two companies. These concise extract-abstracts are then distributed to designated personnel of the client company. Write to E. Corbett, Director, Industrial Patent Research Co., 2266 E. Main St., Columbus 9, Ohio.

(Continued on page 52A)

creativity



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relax and think . . . in Kansas

BOEING - WICHITA

Industrial Notes

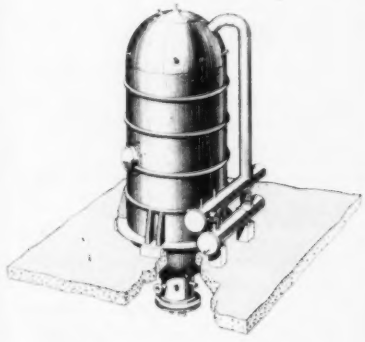
(Continued from page 51A)

Corning Glass Works Bradford, Pa. . .

A new building designed for manufacturing high-purity fused silica has been placed in operation in Bradford, Pa., by Corning Glass Works. The one-story, 7,500-square-foot facility is situated next to Corning's modern electronic components plant. The building will produce fused silica for ultrasonic delay lines and optical applications. Ultrasonic delay lines are designed and manufactured by the electronic components department.

Chicago Bridge & Iron Co. Chicago, Ill. . .

A new evaporator design and construction has been developed to solve atomic age problems in concentrating radioactive wastes which Consolidated Edison Co. of New York, Inc., must dispose of after its new 275,000-kw Indian Point nuclear power plant on the Hudson River goes into service in April 1961. Designed by Chicago Bridge & Iron Co., 332 S. Michigan Ave., Chicago 11, Ill., and currently under construction at its Greenville, Pa., shops, the evaporator will be



made entirely of Inconel (nickel alloy) and have an entrainment section of woven stainless steel six times the usual thickness. The design calls for a welded flangeless unit that will accept wash-down and purge water from the entire plant and vaporize it so effectively that less than 5 parts in 100 million of dissolved solids are in the discharge. An ion exchange unit will cut this minuscule amount to less than 1 part in 100 million as safe as the Hudson River.

Kahn Research Laboratories, Inc. Freeport, N.Y. . .

This company recently moved to new, larger office and plant facilities at 81 S. Bergen Place, Freeport, N.Y. The move will provide much-needed engineering and manufacturing space for the production of single-side-band and compatible single-side-band adapters for high-frequency and broadcast-type AM transmitters.

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For information on select staff openings in several technical specialties, write: Mr. Donald H. Sweet, Executive & Engineering Placement, Raytheon Company, 624 H Worcester Road, Framingham, Massachusetts (suburban Boston).

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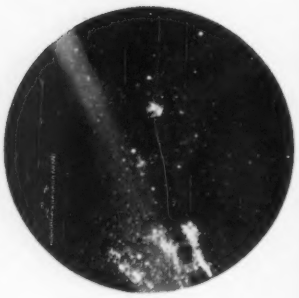

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Trade Literature...

Relay Definitions and Testing Procedures . . .

A 70-page progress report by the National Association of Relay Manufacturers' technical committees on dry circuits (low energy switching); measurement of electrical characteristics; contact life testing; environmental testing including temperature, humidity, altitude, and corrosion; vibration testing; shock, acceleration, and tumbling, presents suggested definitions and test procedures, discusses test equipment and precautions, outlines work yet to be done, and solicits comments and suggestions on work accomplished to date. Write Prof. C. F. Cameron. **National Association of Relay Manufacturers, P. O. Box 6, Stillwater, Okla.**

Fire Extinguishing Systems Booklet . . .

A newly revised booklet on fire extinguishing systems and equipment, called Folio 1-1, lists principal causes of large-loss fires, advantages in the use of carbon dioxide, and examples of extinguishing installations in various industries. Typical systems for the protection of generators, flammable liquids, paint spray rooms and booths, quench and dip tanks, record and fur storage vaults, and pump house and pumping operations are illustrated. **Cardox Division of Chemetron Corp., 840 N. Michgan Ave., Chicago 11, Ill.**

Transformer Catalog . . .

"The Design and Usage of Miniature Pulse Transformers," published by PCA Electronics, Inc., covers the history of low-level pulse transformers, their chief differences compared to other transformer types, methods of measurement, and theory of application. Also included is data on pulse transformer equivalent circuit, transformer polarization, methods of degaussing a core, manufacturing procedures, style, and packaging. **PCA Electronics, Inc., 16799 Schoenborn St., Sepulveda, Calif.**

Industrial Use of Isotopes . . .

A 12-page booklet, "Industrial Radiography with Radioisotopes," describing equipment and methods of radiographing all kinds of industrial products, discusses the advantages peculiar to isotopes in radiography, the selection of the proper isotope for a particular job, and methods of making radiographic exposures. The booklet also contains a chart of equivalent energies showing typical exposure times required to radiograph various materials of varying thicknesses with some of the popular isotopes. **Picker X-Ray Corp., a subsidiary of C.I.T. Financial Corp., 25 S. Broadway, White Plains, N.Y.**

Brochure on Digital Tape Handler . . .

An 8-page brochure on the *FR-400* digital magnetic tape handler includes complete specifications on the machines which are available with ½-, ¾-, or 1-inch tape, providing up to 32 data channels. **Ampex Instrumentation Advertising, 934 Charter St., Redwood City, Calif.**

Insulating Varnishes Catalog . . .

A comprehensive catalog on the selection and application of electrical insulating varnishes with complete details on all electrical and mechanical properties, as well as operating temperature limitations, is available free from Dept. S9-433, **Minnesota Mining and Manufacturing Co., Irvington Division, 900 Bush Ave., St. Paul 6, Minn.**

Scientific Supplies Catalog . . .

Specifications for over 300 exclusive products used in the physical sciences ranging from optical benches and cathetometers to galvanometers and electron impact tubes are described in this 112-page catalog. Through a plan of special supplements to users, the catalog will be kept current on a quarterly basis. Copies may be obtained upon letterhead request to **The Ealing Corp., 40 University Rd., Cambridge, Mass.**

Magnet Wire Booklet . . .

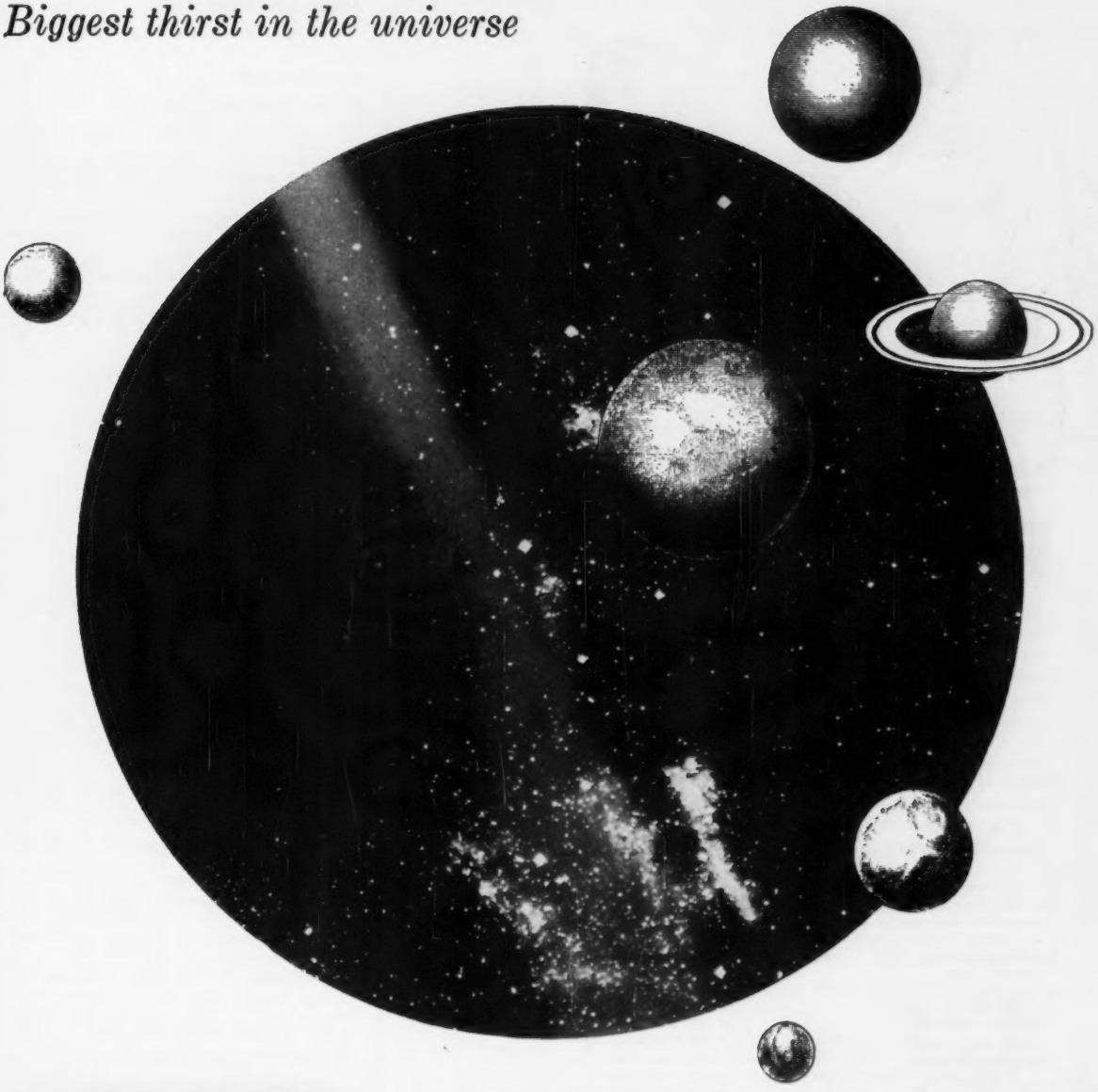
A 19-page publication to help manufacturing maintenance, and repair firms choose the correct magnet wire for hermetic motors, titled "Enameled Magnet Wires for Hermetic Motor Applications," includes a comprehensive table of test data for each of the types of insulation Anaconda recommends for hermetically sealed motor service. These are Anavar, Anatherm, Epoxy, Formvar, and Lecton. **Anaconda Wire and Cable Co., Dept. EFL, 25 Broadway, New York 4, N.Y.**

Bronzeless Gold . . .

The Bronzeless Gold spray finishes, developed and marketed by the Bee Chemical Co., are discussed in an 8-page booklet published by the firm. The new finishes provide an appearance comparable to coatings made by the use of bronze powder but offer advantages over these conventional finishes by being lower in cost, nontarnishing, nongelling, and easier to apply. Bronzeless Golds are available in a full array of matched colors as well as a number of standard colors. **Bee Chemical Co., Logo Division, 12933 S. Stony Island Ave., Chicago 33, Ill.**

(Continued on page 56A)

Biggest thirst in the universe



Each 6,000,000 pound thrust rocket ship now being planned for manned interplanetary exploration will gulp as much propellant as the entire capacity of a 170 passenger DC-8 Jetliner in less than 4 seconds! It will consume 1,140 tons in the rocket's approximately 2 minutes of burning time. Required to carry this vast quantity of propellant will be tanks tall as 8 story buildings, strong enough to withstand tremendous G forces, yet of minimum weight. Douglas is especially qualified to build giant-sized space ships of this type because of familiarity with every structural and environmental problem involved. This has been gained through 18 years of experience in producing missile and space systems. We are seeking qualified engineers and scientists to aid us in these and other projects. Some of our immediate needs are listed on the facing page.

Dr. Henry Ponsford, Chief, Structures Section, discusses valve and fuel flow requirements for space vehicles with Donald W. Douglas, Jr., President of DOUGLAS

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- Antenna design
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- Transistor applications
- Crystal engineering
- Sales engineering
- Design of VHF & UHF FM communications in portable or subminiature development
- Microwave field engineers
- Transistor switching circuit design
- Logic circuit design
- T.V. circuit design engineering
- Home radio design
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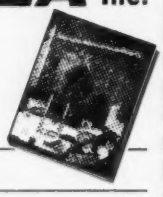

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ADDRESS_____

CITY_____ ZONE____ STATE_____

Trade Literature

(Continued from page 54A)

Multichannel Scaler Analyzer . . .

This 4-page brochure explains new features, operating characteristics, and specifications of the RCLiac *128* multichannel scaler-analyzer which functions as a 128-channel pulse height analyzer and a 125-channel scaler suitable for preset time and preset count gross counting. **Radiation Counter Laboratories, Inc., 5121 W. Grove St., Skokie, Ill.**

Time Delay Relay Catalog . . .

Catalog No. 100, containing the most complete line of economical quality commercial and military thermal time delay relays, is now available from **Ortron Electronics Corp., 29 Lincoln Ave., Orange, N. J.**

Stock Servo Motor Bulletin . . .

The *RBC-2407* stock servo motors for precision instruments and remote positioning systems are described in technical bulletin MO-3.13. Detailed performance ratings and dimensional drawings are given for both gearhead and nongearhead models of the reversible, low-inertia motors. **Holtzer-Cabot Motor Division, National Pneumatic Co., Inc., 125 Amory St., Boston, Mass.**

Chassis Punch Folder . . .

This 4-page folder gives specific information on chassis punches for electronics applications and other uses. This line of more than 20 different sizes and types of punches is said to require 50% less torquing effort than is customary due to an exclusive electrocoating process used on the cutting edges. **Walsco Electronics Mfg. Co., division of Textron Inc., 100 W. Green St., Rockford, Ill.**

"Group Relamping Plan" . . .

A booklet describing a relamping plan for users of large quantities of fluorescent lamps points out how time and money can be saved. Sample calculations help the user calculate his own relamping schedule. For a copy of booklet A-6832, call or write the Westinghouse Lamp Division office nearest you, or write to the **Westinghouse Lamp Division, Box 388, Bloomfield, N. J.**

Fire Prevention Booklets . . .

Two booklets, one dealing with home fires entitled "Before It's Too Late!" and the other dealing with industrial fires entitled "Fred Flame, the Fiery Delinquent," have been published by the **National Safety Council, 425 N. Michigan Ave., Chicago 11, Ill.**

3rd National Conference

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March 1959

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1. Engineering Education for Instrumentation
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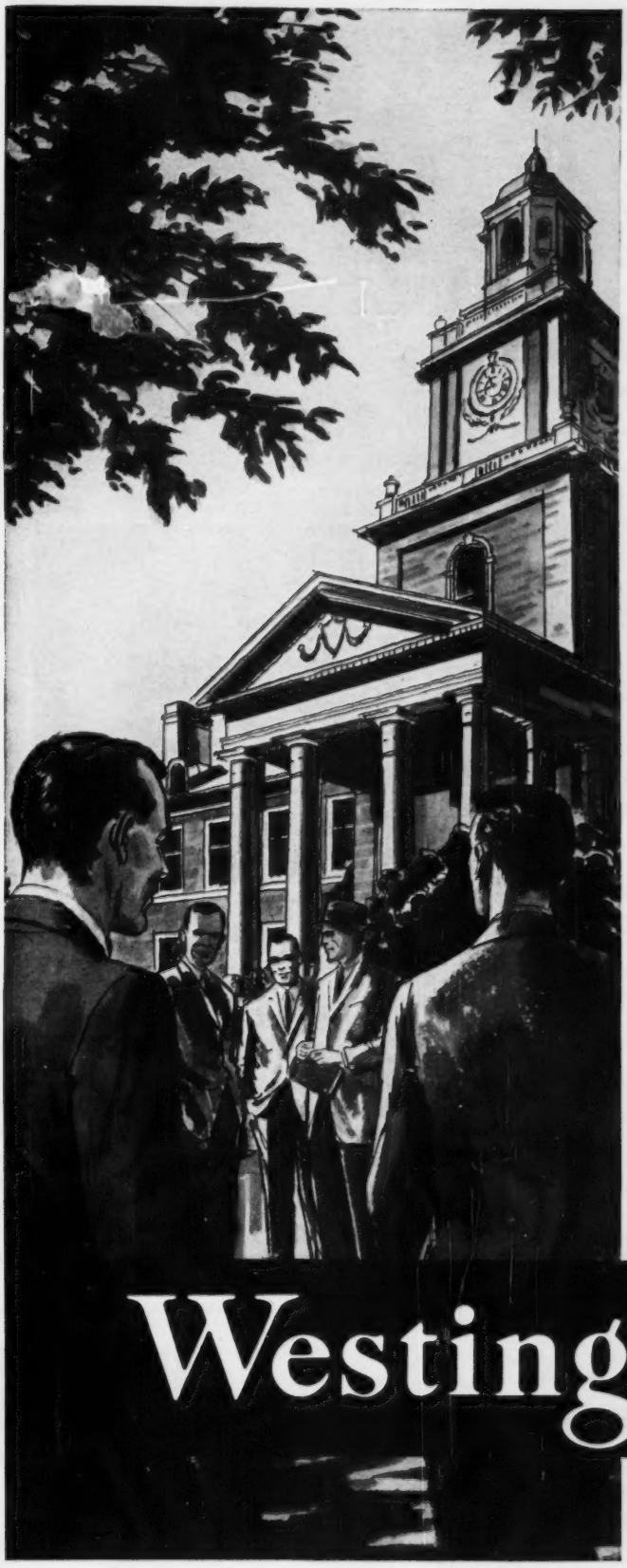

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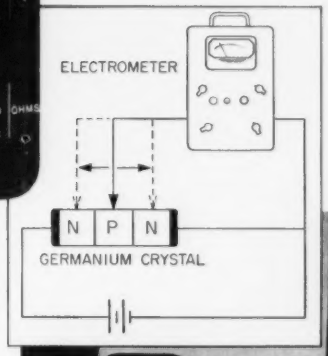

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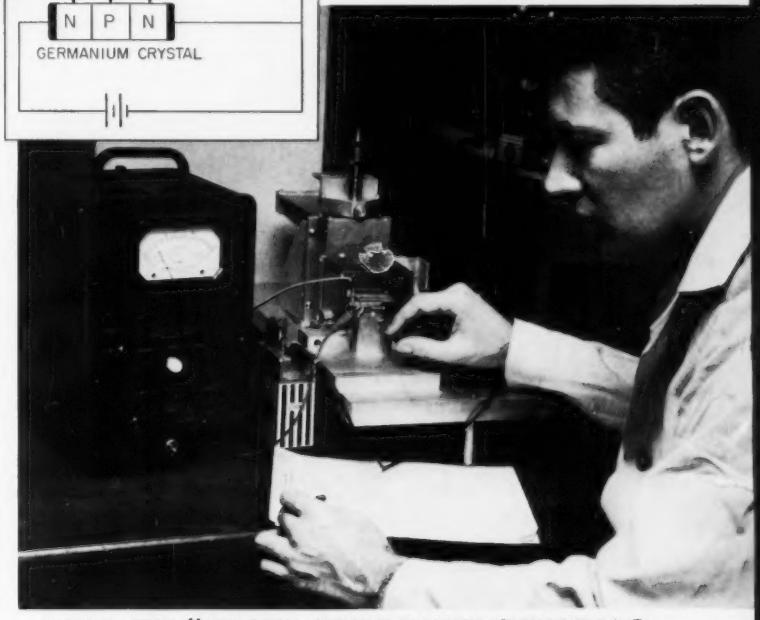

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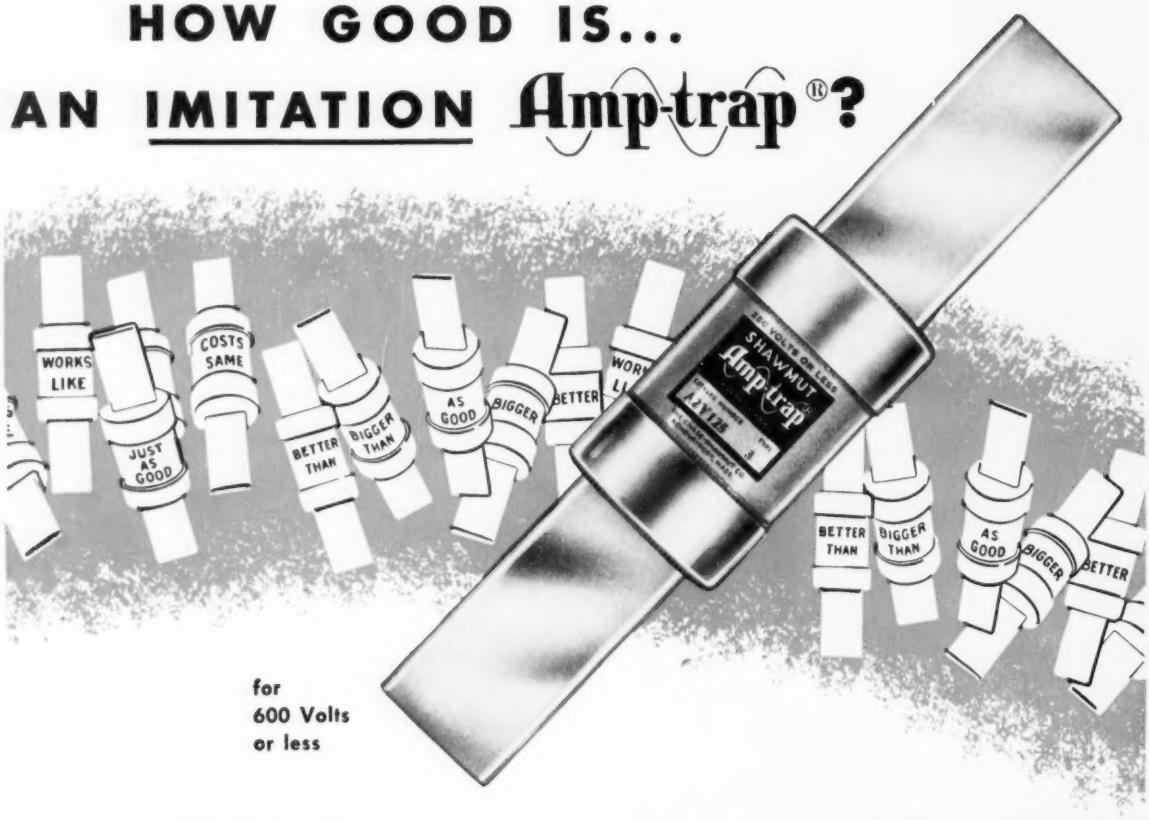

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